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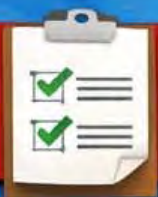


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CHAPTER 1

Exploration: Entering the World of Secondary Science

SUMMARY

1. EXPLORATION: ENTERING THE WORLD OF SECONDARY SCIENCE

1. Science begins with wonder and grows through careful experiments.
2. Secondary stage science focuses on deep exploration.
3. Science is about what we know and also how we know it.
4. The magnifying glass symbolises careful observation and noticing important details.
5. The compass symbolises choosing appropriate models, asking the right questions, and knowing the limits of ideas.
6. Exploration in science tries to make sense of the world with care and purpose.

2. SCIENTIFIC MODELS

1. The natural world is complex and difficult to study in full detail.
2. Science uses simplified models to understand real systems.
3. Models focus only on what is most important to answer a specific question.
4. In physics, a moving car may be represented as a single point.
5. In chemistry, atoms and molecules are drawn as spheres and bonds.
6. In biology, cells are shown as diagrams highlighting only the key parts.
7. In earth science, the Earth is treated as a smooth sphere layered into distinct regions.
8. Building models involves making assumptions and deliberately ignoring certain details.

9. Air resistance is neglected when studying the basic effect of gravity on a falling object.
10. Individual cells are ignored when studying how the heart functions as a pumping organ.
11. Ignoring these details is done on purpose to keep things simple and find answers.

3. MEET A SCIENTIST: MEGHNAD SAHA

1. Meghnad Saha was an Indian physicist who studied the light from stars.
2. He simplified stars by ignoring every atom and complex reaction inside them.
3. He modeled the matter in a star simply as a hot gas.
4. He focused only on temperature, pressure, and how atoms formed ions.
5. This simplification allowed him to explain how the colour of stars is deeply connected to their temperature.

4. LANGUAGE AND MATHEMATICS IN SCIENCE

1. Science uses everyday words like force, work, cell, or reaction in a very careful and precise way.
2. These words have specific and unambiguous meanings in science.
3. Science uses a shared language of specific terms, symbols, and units to describe observations and compare results.
4. Mass is represented by the symbol m .
5. Velocity is represented by the symbol v .
6. Force is represented by the symbol F .
7. Electric current is represented by the symbol I .
8. Science uses mathematics to express relationships between quantities clearly.

9. Mathematics in science is a compact language for thinking, not just a calculation tool.
10. Mathematical equations describe motion, chemical reaction rates, population growth, and energy changes.

5. LAWS, THEORIES, AND PRINCIPLES

1. Repeated observations and experiments organise our understanding of the world.
2. A law describes a regular pattern observed in nature.
3. Laws are often expressed using words or mathematical relationships.
4. Newton's laws of motion explain the jerk felt when a bus stops suddenly.
5. A theory provides an explanation of why those patterns occur based on gathered evidence.
6. The atomic theory explains how molecules are formed.
7. A theory in science is not a guess or an untested idea.
8. Theories are open to improvement and change as new evidence becomes available.
9. Principles are broad ideas that help us make sense of a given situation.
10. The principle of conservation of energy is applied when understanding climbing up stairs.

6. PREDICTIONS IN SCIENCE

1. One of the greatest strengths of science is its ability to make predictions.
2. Laws, theories, and models allow scientists to anticipate what will happen under new conditions.
3. Knowledge of motion predicts how far a kicked football will travel.
4. Knowledge of chemical reactions estimates how much carbon dioxide is produced in baking.
5. Biological principles predict how a person's breathing changes while running.
6. Scientific predictions are reasoned expectations based on evidence and careful thinking, not guesses.
7. Confidence in science grows when predictions match observations.
8. When predictions fail, scientists re-examine their assumptions, models, and measurements.

7. LIMITS OF SCIENTIFIC THEORIES

1. Even the most successful scientific theories have limits.
2. Theories may fail when new conditions are explored or measurements become more precise.
3. Failures are not a weakness but the greatest strength of science.
4. Scientists reject ideas only based on evidence, never on opinion or belief.
5. No scientific theory is ever final and none is beyond question.
6. Science is always open to being corrected by nature itself.

8. THE POWER OF ESTIMATION

1. A helpful scientific strategy is to understand the situation, identify important quantities, and make a rough estimate.
2. Approximate estimates help tell us whether a calculated result is reasonable or impossible.
3. Exact values are not always necessary in the early stages of reasoning.
4. Learning to estimate helps build intuition and detect errors.
5. Estimation develops confidence in thinking.
6. Science values careful reasoning perhaps much more than accurate calculations.

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9. BRANCHES OF SCIENCE

1. Science is divided into branches like physics, chemistry, biology, and earth science to help organise knowledge.
2. The natural world does not actually have these strict boundaries.
3. Branches of science are not independent of each other.
4. Understanding real-world problems like climate change or developing medicines requires ideas from several disciplines.
5. Science naturally connects with mathematics, technology, arts, and social sciences to fully make sense of the world.

10. THE NATURE OF SCIENCE

1. Science is not just a collection of facts, equations, or experiments.
2. Science is a human activity shaped by curiosity, creativity, collaboration, and careful questioning.
3. Science grows as people ask questions, test ideas, share results, and learn from mistakes.
4. Science develops over time through the work of many individuals across different cultures.
5. Scientific thinking helps evaluate information critically and understand surrounding technology.
6. Science invites students to learn about the world and also learn how we are trying to understand it.

PAUSE AND PONDER

1. Think of a prediction you or your family made recently (for example, the outcome of a cricket match). Was it based on evidence and reasoning, or mainly on guesswork? How can scientific thinking improve such predictions?

Ans :

Recently, my family predicted that it would rain heavily during the evening based purely on guesswork after looking at some slightly dark clouds. Scientific thinking could significantly improve such predictions by shifting the focus from simple observations to measurable evidence and past patterns. For instance, instead of just looking at the clouds, we could ask scientific questions about current humidity levels, wind speed, and atmospheric pressure drops to make a much more reliable and reasoned forecast.

2. Describe one situation where an approximate answer is good enough, and one where you would need a very exact value.

Ans :

An approximate answer is good enough when estimating how much rice would feed a family for a month, as a rough calculation of daily calories helps check if a bulk purchase makes sense without needing to count every grain. Conversely, a very exact value is absolutely necessary when calculating the amount of fuel

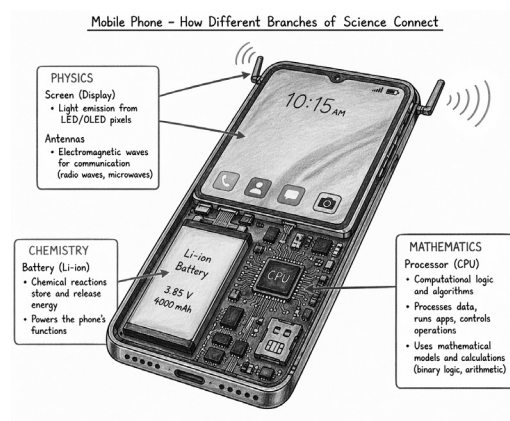
required for a passenger aircraft mid-flight. Using an approximate value or mixing up units in such a scenario can lead to disastrous consequences, such as the aircraft running completely out of fuel before safely reaching its destination.

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3. Choose a real-life object (maybe a pressure cooker or a mobile phone) or a problem (maybe a traffic jam near your school). Make a sketch listing what kind of ideas from physics, chemistry, biology, earth science, or mathematics are involved. Show how at least two branches of science connect with your example.

Ans :

You should draw a sketch of a mobile phone with text labels pointing to the battery for Chemistry (chemical reactions storing energy), the screen and antennas for Physics (light emission and electromagnetic waves), and the internal processor for Mathematics (computational logic and data processing). These branches of science connect deeply in this device because the chemical properties of the battery materials (Chemistry) must provide the exact continuous electrical voltage required to power the internal circuits and transmit radio signals (Physics). Together, these interconnected scientific principles allow the phone to function properly as a reliable tool.



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OBJECTIVE QUESTIONS

1. As per the textbook's introductory philosophy, what does the magnifying glass primarily symbolize in the context of scientific exploration?
- Choosing the correct mathematical equations
 - Noticing patterns and careful observation
 - Providing a direction for scientific theories
 - Measuring exact physical quantities

Ans : (B)

The magnifying glass is a powerful symbol representing the core scientific practice of careful observation. It emphasizes the absolute necessity to notice hidden patterns and pay close attention to critical details that might otherwise be completely missed. This fundamental observational skill is essential for building a strong foundation in any meaningful scientific inquiry and investigation.

2. While the magnifying glass represents observation, what does the compass symbolise according to the textbook's approach?
- Asking the right questions and choosing appropriate models
 - Magnifying small particles to understand atomic structure
 - Calculating the exact geographical location of an experiment
 - Finding the precise numerical answer without reasoning

Ans : (A)

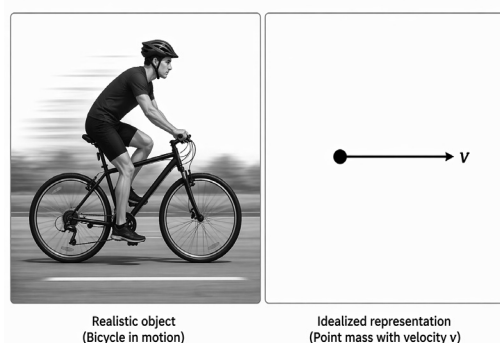
The compass conceptually symbolizes that scientific exploration requires proper direction and purpose. It represents the vital processes of choosing appropriate models, asking the right testable questions, and thoroughly knowing the limits of where our ideas apply. Together with observation, it ensures that scientific discovery is a targeted effort rather than just aimlessly wandering through data.

3. What is the primary purpose of building models in science to study the complex natural world?
- To replicate every single detail of the real system
 - To complicate theories to make them mathematically rigorous
 - To simplify real systems by focusing only on important details
 - To ensure that no assumption is ever made during research

Ans : (C)

The natural world is incredibly complex, making full-detail study nearly impossible. Therefore, science utilizes models as simplified representations of real systems. By deliberately focusing solely on the most critical elements and purposefully ignoring less relevant details, these models allow scientists to systematically analyse phenomena and find clear answers without being overwhelmed by unnecessary complexity.

4. Why is the detailed physical object on the left frequently represented by the simplified geometric model on the right in introductory physics?



- To ensure all minor physical forces are accurately captured in the final calculation.
- To isolate and focus only on the most essential variables required to solve a specific problem.
- To demonstrate that complex physical characteristics have absolutely no influence on overall motion.
- To compensate for the inability of modern scientific tools to measure intricate real-world details.

Ans : (B)

In science, models deliberately simplify complex reality by intentionally ignoring specific details. Representing a moving vehicle as a point mass focuses solely on essential variables like mass and velocity. This intentional simplification makes the problem mathematically manageable while still providing accurate answers for fundamental questions, avoiding unnecessary complications from minor real-world features.

5. In physics, how might a moving car be appropriately represented using a simple scientific model?
- As a complex structure of individual atoms
 - As a single point in space

- (C) As a diagram highlighting key biological parts
 (D) As a smooth sphere layered into distinct regions

Ans : (B)

In physics, when analyzing broad concepts like motion, simplified models are highly effective. A moving car, despite its structural complexity, is often represented as a single point. This specific simplification allows physicists to entirely focus on fundamental quantities like speed, distance, and time, deliberately ignoring extraneous details such as the car's shape or internal mechanics.

6. The table outlines four different scientific models created by students to study various real-world phenomena. Each model includes certain variables while deliberately ignoring others. Based on the principles of scientific modeling, which model demonstrates an invalid approach to simplification?

Scientific Model	Phenomenon Being Studied	Key Variables Included	Variables Deliberately Ignored
Model I	Motion of a falling rock	Mass, Gravity	Air resistance, Rock color
Model II	Light emitted by a star	Overall temperature, Pressure	Individual atomic reactions
Model III	Flight of a hit cricket ball	Bat brand, Grass color	Mass of ball, Wind speed
Model IV	Pumping of a human heart	Blood volume, Flow rate	Individual muscle cell function

- (A) Model I
 (B) Model II
 (C) Model III
 (D) Model IV

Ans : (C)

Effective scientific models simplify complex reality by focusing on essential variables and ignoring irrelevant details. Model III is invalid because it retains arbitrary details, such as bat brand and grass color, while deliberately ignoring critical physical factors like mass and wind speed that are absolutely necessary to study motion accurately.

7. When studying the fundamental motion of a falling object in physics, which specific factor is frequently neglected to understand the basic effect of gravity?
 (A) The object's mass

- (B) The height of the fall
 (C) Air resistance
 (D) The acceleration due to gravity

Ans : (C)

When scientists create a basic model to study the pure effect of gravity on a falling object, they often deliberately neglect air resistance. This strategic omission simplifies the problem significantly, allowing researchers to isolate and clearly understand how gravity alone influences the object's downward acceleration without the complicating, variable interference of atmospheric friction forces.

8. Imagine modeling a cricket ball hit for a six to determine if it crosses the boundary. Which detail is essential to include?
 (A) The brand of the cricket bat
 (B) The colour of the grass on the field
 (C) The speed and direction of the hit
 (D) The stitching of the threads at the seam

Ans : (C)

To accurately predict whether a cricket ball will cross the boundary, the model must include crucial mechanical factors like the speed and direction in which it was hit. These primary variables directly determine the trajectory and final distance. In contrast, aesthetic details like bat brands or minor factors like seam stitching have negligible effects here.

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9. In the same cricket ball model determining boundary clearance, which detail can be safely ignored for a basic calculation?
 (A) The mass of the ball
 (B) The speed of the hit
 (C) The direction of the hit
 (D) The brand of the bat

Ans : (D)

When constructing a simple mathematical model to calculate the trajectory of a struck cricket ball, aesthetic and non-physical attributes like the specific brand of the bat play absolutely no role. Ignoring such completely irrelevant details is a standard scientific modeling practice, allowing researchers to concentrate exclusively on the critical physical variables that actually govern motion.

10. How did physicist Meghnad Saha successfully model the matter inside a star to explain its colour?

(A) By tracking every single atomic reaction inside the star
 (B) By treating the matter purely as a hot gas
 (C) By calculating the exact mass of every internal element
 (D) By focusing heavily on complex gravitational waves

Ans : (B)

Physicist Meghnad Saha brilliantly simplified the unimaginable complexity of stars by treating their internal matter simply as a hot gas. Instead of attempting to model every single complex atomic reaction, he exclusively focused on fundamental macroscopic properties like temperature and pressure. This powerful simplification directly allowed him to successfully explain how star colour connects to temperature.

11. What specific details did Meghnad Saha purposefully ignore when developing his simplified model of stars?

(A) Temperature and pressure
 (B) How atoms formed ions
 (C) Many complex atomic reactions and individual atom movements
 (D) The visible light emitted from the star

Ans : (C)

To make his stellar model functionally workable, Meghnad Saha purposefully ignored the overwhelmingly complex individual atomic reactions and the precise movements of every single atom inside the star. By stripping away these highly intricate microscopic details, he successfully concentrated his mathematical analysis on broader thermodynamic factors, proving that intentional simplification is crucial for scientific breakthroughs.

12. Consider the following statements regarding the shared language of science:

1. Science uses specific terms with unambiguous meanings.
2. Shared language allows scientists globally to compare results accurately.
3. Scientific quantities are never associated with defined standardized units.

Which of the above statements is/are correct?

(A) 1 and 2 only
 (B) 2 and 3 only

(C) 1 and 3 only

(D) 1, 2, and 3

Ans : (A)

Science absolutely relies on a carefully structured shared language featuring specific terms with entirely unambiguous meanings. This precision allows global scientists to describe observations uniformly and build ideas together. However, statement three is distinctly incorrect because physical quantities in science, such as mass or velocity, are always strictly associated with clearly defined, internationally standardized units.

13. The measuring device shown in the image relies on universally accepted standard weights, such as the kilogram. What is the primary scientific reason for establishing these international standards?



- (A) To guarantee that measurements perfectly match absolute and unchanging theoretical values without any error.
 (B) To ensure that scientific observations and everyday measurements are globally consistent and easily comparable.
 (C) To eliminate the need for mathematical equations when calculating physical quantities in scientific experiments.
 (D) To prevent the use of traditional or localized measuring tools when conducting basic scientific research.

Ans : (B)

Standardized units are crucial in scientific inquiry because they establish a universally agreed-upon framework for measuring physical quantities. This international consistency ensures that complex experimental results, everyday commerce, and general observations can be accurately communicated, systematically compared, and reliably replicated by researchers and individuals, regardless of their geographical location.

14. According to the textbook, what is the primary role of mathematics in the realm of science?
- It serves merely as an isolated tool for complex numerical calculations.
 - It functions as a specialized language providing compact statements about relationships.
 - It acts as a deliberate hurdle to ensure only experts understand physics.
 - It replaces the need for actual physical experimental observations.

Ans : (B)

Mathematics is distinctly not meant to be a restrictive hurdle or a mere calculation tool. Instead, it functions as an essential, powerful language that helps scientists think more clearly about the world. An equation is essentially a highly compact, logical statement meticulously describing exactly how various physical quantities and natural phenomena are deeply related to each other.

15. Four students recorded measurements during a physics experiment. The table displays the physical quantities they measured, along with the scientific symbols and units they applied. Which student correctly paired the physical quantity with both its proper scientific symbol and its standard unit?

Student	Physical Quantity	Symbol Used	Measurement Unit Applied
Student A	Force	F	Kilogram
Student B	Velocity	v	Meter per second
Student C	Mass	m	Newton
Student D	Electric Current	I	Volts

- Student A
- Student B
- Student C
- Student D

Ans : (B)

In scientific communication, specific quantities must be paired with standard symbols and units. Student B correctly pairs velocity with the symbol 'v' and the unit 'meters per second'. The other students incorrectly mismatch their standard units, such as applying kilograms for force, Newtons for mass, or Volts for electric current.

16. What specific error caused the well-known incident where a passenger aircraft famously ran out of fuel mid-flight?
- A severe mechanical failure in the aircraft's fuel injection system
 - The extreme evaporation of aviation fuel due to high altitude heat
 - A critical miscalculation mixing up pounds and kilograms per litre
 - The ground crew forgetting to physically attach the refueling hose

Ans : (C)

The dangerous mid-flight fuel exhaustion occurred precisely due to a critical unit mix-up by the ground crew. They incorrectly calculated the required fuel mass using the density in pounds per litre rather than the strictly required kilograms per litre. This significant numerical error highlights why utilizing consistent standard units everywhere is absolutely crucial for safety.

17. Why is the universal adoption of standard units (SI) considered absolutely essential in daily life and trade?
- Because they are based strictly on ancient historical local opinions
 - To intentionally confuse ordinary buyers in the marketplace
 - To ensure fairness in trade and allow scientific results to be compared
 - Because non-standard units cannot physically measure heavy masses

Ans : (C)

Standard units are universally essential because they completely eliminate the immense confusion that would arise from using variable local measurements. By strictly relying on internationally agreed standards, we actively ensure undeniable fairness in daily commercial trade. Furthermore, standard units allow critical scientific experimental results to be accurately communicated, systematically compared, and reliably verified across the globe.

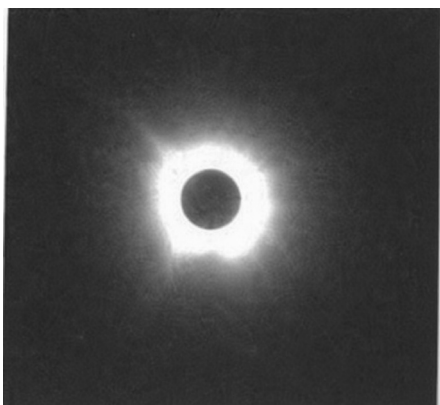
18. **Assertion (A):** The speed of light is universally denoted by the specific scientific symbol 'c'.
Reason (R): The symbol 'c' originates from the Latin word 'celeritas', which translates to speed.
- Both A and R are true and R is the correct explanation of A
 - Both A and R are true but R is not the correct explanation of A

- (C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Both the assertion and the reason are factually correct, and the reason provides the exact historical and linguistic explanation for the assertion. Scientific symbols often possess distinct historical roots based on widespread international agreements. Specifically, denoting the speed of light as 'c' directly stems from 'celeritas', the ancient Latin term explicitly meaning speed or swiftness.

19. The astronomical event shown in the image is sometimes linked to unscientific claims, such as food becoming toxic during its occurrence. How does scientific thinking systematically evaluate such a claim?



- (A) By accepting the claim as a valid hypothesis until advanced technology can definitively prove it incorrect.
(B) By relying on long-standing historical beliefs that have been widely accepted by local communities.
(C) By formulating testable questions about measurable physical or chemical changes occurring during the event.
(D) By creating complex mathematical models to prove that celestial bodies always influence biological systems.

Ans : (C)

Science systematically evaluates unconventional claims by asking precise, testable questions based on measurable physical evidence. To investigate whether an astronomical event affects food, scientists look for identifying physical mechanisms, such as significant temperature changes or chemical reactions, rather than accepting unverified assertions based purely on popular belief or opinion.

20. Today, the fundamental physical constant for the speed of light is precisely defined to be exactly:
(A) 300,000,000 m/s
(B) 299792458 m/s
(C) 299000000 m/s
(D) 299792000 m/s

Ans : (B)

Scientific constants require absolute precision for universally accurate calculations. Currently, based on strict international scientific agreements, the speed of light in a vacuum is rigorously defined as an exact physical constant. Its precise numerical value is universally established as exactly 299792458 metres per second, providing an unwavering baseline foundation for modern advanced physics and accurate astronomical measurements.

21. In the specific context of scientific terminology, what exactly does a "Law" typically describe?
(A) An untested, speculative guess about future biological events
(B) A detailed theoretical explanation of why natural events happen
(C) A regular, predictable pattern repeatedly observed in nature
(D) A highly simplified visual diagram of a complex physical system

Ans : (C)

In scientific terminology, a "law" serves a very specific and fundamental purpose. It consistently describes a regular, highly predictable pattern that is repeatedly observed throughout nature. These observable patterns are most often expressed concisely using straightforward descriptive words or rigid mathematical relationships, definitively stating what consistently happens under certain specific physical conditions without necessarily explaining why.

22. Which of the following examples perfectly illustrates a scientific 'Law' as directly mentioned in the chapter?
(A) The atomic theory explaining fundamental molecular formations
(B) Newton's rules explaining the physical jerk felt when a bus stops
(C) The general principle of massive energy conservation
(D) Meghnad Saha's simplified hot gas model of stellar structures

Ans : (B)

Newton's laws of motion to clearly illustrate the concept of a scientific law. These specific laws perfectly describe regular, consistent patterns observed in physical motion. For instance, they reliably predict and quantify the backward or forward physical jerk a passenger predictably experiences when a moving bus suddenly accelerates or abruptly stops.

23. Two students are trying to predict whether it will rain on Friday. One student simply looks at the dark clouds and guesses it will rain. The other student uses the historical weather data provided in the table. What logical, scientifically testable conclusion should be drawn for Friday?

Day	Condition of Sky	Humidity (%)	Wind Speed (km/h)	Did it rain?
Monday	Dark Clouds	85	22	Yes
Tuesday	Light Clouds	40	10	No
Wednesday	Dark Clouds	88	25	Yes
Thursday	Dark Clouds	45	12	No
Friday	Dark Clouds	82	20	Prediction Needed

- (A) It will not rain because dark clouds never guarantee rain.
 (B) It will rain because high humidity and high wind speed are present alongside dark clouds.
 (C) It will rain solely because the clouds are dark, validating the first student's guess.
 (D) It will not rain because the wind speed is slightly lower than it was on Wednesday.

Ans : (B)

Scientific predictions are reasoned expectations based on measurable evidence and past patterns rather than subjective guesswork. The tabulated data reveals that rain consistently occurred only when dark clouds were accompanied by high humidity and high wind speeds. Therefore, Friday's identical measurable conditions strongly and logically support the prediction of rain.

24. While a scientific law describes an observed pattern, what crucial deeper insight does a "theory" provide?
 (A) It offers an explanation of exactly why those specific patterns occur.

- (B) It provides a random, completely untested guess about future outcomes.
 (C) It describes a rigid mathematical equation that can never be altered.
 (D) It limits the boundary conditions where the scientific law applies.

Ans : (A)

A theory represents a significantly deeper level of scientific understanding than a mere descriptive law. It comprehensively provides a logical, structured explanation detailing exactly why those observed natural patterns persistently occur. Theories are robustly constructed upon massive foundations of carefully gathered evidence, meticulously tested over extended periods, making them highly reliable explanatory frameworks in science.

25. Which prominent scientific concept is specifically cited in the textbook as an explanation for how molecules are formed?
 (A) The principle of energy conservation
 (B) Newton's laws of motion
 (C) The atomic theory
 (D) The theory of special relativity

Ans : (C)

The textbook explicitly references the atomic theory as a primary, classic example of a robust scientific theory. This fundamental theory beautifully explains the deeply complex unseen mechanisms governing exactly how individual atoms chemically interact, bond together, and structurally arrange themselves to successfully form all the vast varieties of molecules found throughout the known natural universe.

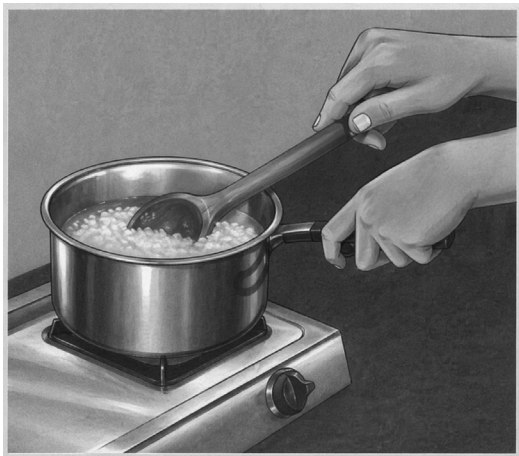
26. In the carefully structured language of science, broad ideas that help us make sense of a given situation are definitively termed as:
 (A) Scientific Guesses
 (B) Principles
 (C) Unverified Hypotheses
 (D) Mathematical Variables

Ans : (B)

In strict scientific terminology, principles are definitively categorized as broad, fundamental ideas that reliably help researchers systematically make sense of specific physical situations. They act as essential guiding frameworks for scientific reasoning. A classic example mentioned is the foundational principle of conservation of energy,

which practically applies uniformly to everyday actions like climbing up steep stairs.

27. Activities like cooking the food shown in the image can be used to practice scientific estimation, such as calculating a family's daily calorie requirements. What is the main value of making rough estimates in scientific reasoning?



- (A) It replaces the need for precise measurements when conducting complex laboratory experiments.
- (B) It helps in determining whether a calculated result is logically reasonable or practically impossible.
- (C) It provides the exact numerical data required to establish new foundational scientific laws.
- (D) It eliminates the necessity of using standardized units when solving everyday physical problems.

Ans : (B)

Rough estimation is a highly valuable scientific skill used to build logical intuition and verify calculations. While it does not yield perfectly exact numbers, it allows scientists and students to quickly evaluate whether a calculated result or a proposed solution makes practical sense within the context of the real world.

28. Which statement most accurately reflects the true nature of well-established scientific theories?
- (A) They are absolute, final truths that can never be questioned.
 - (B) They are mere guesses without any experimental evidence.
 - (C) They are always open to critical improvement as new evidence emerges.
 - (D) They exclusively rely on mathematical calculations without physical observation.

Ans : (C)

A fundamental characteristic of science is its inherent adaptability. Scientific theories are never considered absolute dogmas or unquestionable final truths. Instead, they remain permanently open to rigorous critical examination and progressive improvement. As technological advancements provide fresh, highly reliable new evidence, established theories are frequently modified, updated, or occasionally entirely changed to reflect deeper natural realities.

29. Match the scientific terms in List-I with their correct conceptual definitions from List-II.

List-I (Term)

- P. Law
- Q. Theory
- R. Principle
- S. Model

List-II (Definition)

- 1. Broad over arching ideas that help make sense of a given situation
- 2. Simplified ways of accurately looking at complex real systems
- 3. Describes a regular, predictable pattern observed in nature
- 4. Provides a robust explanation of why specific patterns occur

- (A) P-3, Q-4, R-1, S-2
- (B) P-4, Q-3, R-2, S-1
- (C) P-3, Q-1, R-4, S-2
- (D) P-2, Q-4, R-1, S-3

Ans : (A)

A 'Law' describes a regular observed pattern (P-3). A 'Theory' goes further by providing a comprehensive evidence-based explanation of why those patterns occur (Q-4). A 'Principle' represents a broad overarching idea helping us understand specific situations (R-1). Finally, a 'Model' is a deliberately simplified representation of complex real systems (S-2).

30. Consider the following statements regarding the power of prediction in science:

- 1. Scientific predictions are generally unfounded, random guesses.
- 2. Predictions allow scientists to precisely anticipate outcomes under entirely new conditions.
- 3. Predictions must always be reasoned expectations based heavily on prior evidence.
- 4. When highly accurate predictions match observations, confidence in the underlying science grows.

Which combination of statements is completely correct?

- (A) 1, 2, and 3
- (B) 2, 3, and 4
- (C) 1, 3, and 4
- (D) 1, 2, and 4

Ans : (B)

Statements 2, 3, and 4 correctly describe scientific predictions. They are meticulously reasoned expectations deeply rooted in evidence, entirely allowing scientists to anticipate results under new conditions, thereby building confidence. Conversely, statement 1 is completely false because scientific predictions drastically differ from random, unfounded guesses; they require rigorous logical deduction and solid empirical backing.

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- 31.** Estimation is an important scientific skill used to verify if calculations make logical sense. Four families calculated their estimated daily staple food requirement for one adult. Based on the nutritional data provided in the table, which family calculated a reasonable rough estimate?

Family	Average Adult Energy Need (kcal/day)	Energy per 100g of Staple Food (kcal)	Estimated Staple Food Required per Adult (g/day)
Family W	2200	350	60
Family X	2200	350	600
Family Y	2200	350	6000
Family Z	2200	350	60000

- (A) Family W
- (B) Family X
- (C) Family Y
- (D) Family Z

Ans : (B)

Rough estimation helps verify whether a calculated scientific result makes logical sense. An average adult requires approximately 2200 kilocalories daily. Since 100 grams of the staple food provides 350 kilocalories, consuming 600 grams yields 2100 kilocalories. This makes Family X's calculation a highly accurate and reasonable estimate compared to the others.

- 32.** When Varsha simply predicted rain stating "the clouds look dark", what kind of scientific questions could Meghna ask to make this testable?

- (A) Questions based entirely on personal emotional feelings about rain.
- (B) Questions seeking clear measurable data like current humidity and past patterns.
- (C) Questions that only require simple, unverified yes or no answers.
- (D) Questions about the aesthetic beauty and shape of the dark clouds.

Ans : (B)

To scientifically validate a casual prediction like "clouds look dark", researchers must ask rigorous, analytically testable questions. Meghna should specifically request objective, measurable data such as current atmospheric humidity percentages, noticeable temperature drops, and recent wind directions. Comparing these precise measurable variables strictly against established past weather patterns elevates a mere guess into scientific investigation.

- 33.** Why do highly advanced scientific weather forecasts sometimes still fail when predicting conditions further into the future?

- (A) Because meteorologists generally do not use mathematics.
- (B) Because weather relies heavily on constant, unchanging environmental factors.
- (C) Because tiny initial differences in complex variables can grow drastically over time.
- (D) Because scientific theories completely ignore variables like temperature and pressure.

Ans : (C)

Weather forecasting involves profoundly complex natural systems inherently dependent on continuously shifting factors like temperature, atmospheric pressure, and varied wind patterns. In such chaotic systems, even microscopically tiny initial differences or measurement variations can grow exponentially over extended time. This inherent complexity makes distant long-term predictions notoriously unreliable, despite utilizing highly advanced scientific models.

- 34.** How does the scientific community generally view the inherent limits and occasional failures of even the most successful scientific theories?

- (A) As embarrassing fundamental flaws that completely destroy scientific credibility.

- (B) As absolute proof that mathematical models are entirely useless.
- (C) As its greatest strength, showing openness to being directly corrected by nature.
- (D) As clear evidence that traditional myths are vastly superior to science.

Ans : (C)

Paradoxically, the absolute openness to being proven wrong is recognized as science's greatest conceptual strength. When an established theory unexpectedly fails under new experimental conditions, it directly highlights that science humbly allows nature itself to correct human misunderstandings. This ongoing, rigorous self-correction completely ensures that our comprehension of the complex universe continually improves and strictly aligns with reality.

- 35. Assertion (A):** No accepted scientific theory is ever considered final, and absolutely none is permanently beyond questioning.

Reason (R): Scientists rapidly reject established ideas based purely on shifting popular opinions and social beliefs.

- (A) Both A and R are true and R is the correct explanation of A
- (B) Both A and R are true but R is not the correct explanation of A
- (C) A is true but R is false
- (D) A is false but R is true

Ans : (C)

The assertion correctly states that all scientific theories remain permanently open to critical revision and questioning. However, the reason is fundamentally false. The scientific method is incredibly strict; scientists absolutely never reject robust ideas based on fleeting opinions or popular beliefs. They exclusively revise or discard theories based on solid, verifiable, and newly discovered empirical evidence.

- 36.** Scientists confidently reject the widely circulated viral claim that “food inevitably becomes highly harmful if eaten during a solar eclipse” because:
- (A) Eclipses are exceedingly rare phenomena that scientists cannot observe.
 - (B) An eclipse is merely a simple play of shadows causing no chemical change.
 - (C) The temperature plunges dangerously low, immediately freezing all food items.
 - (D) Ancient philosophical texts definitively proved the claim completely accurate long ago.

Ans : (B)

By applying fundamental scientific questioning, researchers quickly realize an eclipse is merely a standard optical play of celestial shadows. Rigorous investigation confirms there is absolutely no significant temperature crash, and crucially, absolutely no underlying physical, chemical, or biological mechanism exists that could miraculously alter food properties. Thus, science immediately rejects such baseless viral claims through evidence.

- 37.** Understanding how the safety devices shown in the image function requires knowledge of particle motion, polymer properties, and viral behaviour. Which key characteristic of scientific inquiry does this best illustrate?



- (A) Real-world problems are complex and typically require integrating concepts from multiple branches of science.
- (B) Scientific disciplines are strictly separated and rarely share methodologies in practical applications.
- (C) Biological challenges can only be effectively addressed using theoretical principles from biology alone.
- (D) Mathematical equations are the sole requirement for designing and evaluating effective protective equipment.

Ans : (A)

The natural world operates without rigid boundaries between different scientific subjects. Solving practical, real-world problems—such as designing effective protective masks—requires actively connecting fundamental ideas from physics, chemistry, biology, and mathematics. This demonstrates that distinct scientific disciplines are highly interconnected and consistently enrich one another to advance technological innovation.

38. A student constructs a table to demonstrate how different branches of science help us understand the complex functionality of a safety mask. Based on the scientific concepts provided, which two rows contain an incorrect swapping of their primary scientific disciplines?

Row	Mask Function / Feature	Primary Branch of Science	Scientific Concept Applied
Row 1	Electrostatic layers	Physics	Particle motion and electrostatic attraction
Row 2	Material composition	Biology	Properties of polymer fibres
Row 3	Pathogen filtration	Chemistry	Size and behaviour of viruses
Row 4	Breathability design	Mathematics	Modelling airflow and filtration efficiency

- (A) Row 1 and Row 2
 (B) Row 2 and Row 3
 (C) Row 3 and Row 4
 (D) Row 1 and Row 4

Ans : (B)

Solving real-world problems requires connecting multiple scientific disciplines. Chemistry studies the specific properties of materials, such as the chemical composition of polymer fibers. Conversely, biology focuses on biological entities, examining the size and behavior of viruses. The table incorrectly swaps these disciplines, misattributing fibers to biology and viruses to chemistry.

39. What specific practical strategy is highly recommended in the early stages of reasoning to quickly determine whether a calculated scientific result makes sense?
- (A) Performing highly complex, precise decimal calculations immediately
 (B) Conducting a fully funded, decade-long laboratory experiment
 (C) Making a rough, approximate estimate to check general reasonableness
 (D) Assuming the first intuitive guess is absolutely flawless and final

Ans : (C)

In the very early stages of scientific problem-solving, making a rough, approximate estimate is an incredibly powerful strategy. This practical

approach does not require immediate, exhaustive precision. Instead, it rapidly helps researchers confidently determine whether their initial theoretical result is logically reasonable or glaringly impossible, ultimately building strong foundational intuition and quickly detecting major calculation errors.

40. Why is actively learning to estimate effectively considered such an exceptionally important scientific skill?
- (A) It permanently eliminates the need for any actual experimental measurements.
 (B) It helps steadily build intuition, rapidly detect errors, and develop confidence.
 (C) It provides absolutely precise final answers without requiring mathematics.
 (D) It actively discourages students from pursuing advanced theoretical physics.

Ans : (B)

Rough estimation is heavily emphasized as a highly crucial scientific skill primarily because it systematically helps students fundamentally build robust physical intuition. By quickly estimating values, one can effortlessly detect massive calculation errors early on. This vital process rapidly develops immense intellectual confidence, proving that logical scientific reasoning often holds more practical value than strictly rigid, accurate calculations.

41. Consider the following statements regarding the estimation of how much rice would feed a family:
- Getting a perfectly exact decimal number is the primary goal of this exercise.
 - The fundamental aim is strictly to logically check whether the final answer physically makes sense.
 - Such estimation deeply helps seamlessly connect abstract science to practical everyday questions.

Which combination represents correct statements?

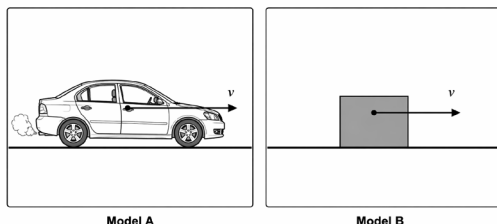
- (A) 1 and 2 only
 (B) 2 and 3 only
 (C) 1 and 3 only
 (D) 1, 2, and 3

Ans : (B)

When executing a rough scientific estimate, such as calculating a family's monthly rice requirement, obtaining a perfectly precise decimal figure is distinctly not the goal. Instead, the primary objective is to logically verify if the general

magnitude makes practical sense. Importantly, this immensely valuable exercise beautifully connects abstract scientific reasoning directly to highly relevant everyday situations.

42. Why would a physicist choose to use Model B instead of Model A when calculating the time taken for the object to travel a specific straight-line distance?



- (A) Model B includes more complex assumptions to ensure greater real-world accuracy.
 (B) Model B deliberately ignores details that do not affect basic linear motion.
 (C) Model B represents a biological system rather than a physical one.
 (D) Model B proves that the visual appearance of an object changes its speed.

Ans : (B)

Science uses simplified models to make sense of complex reality. By treating a moving car as a basic geometric shape, physicists deliberately ignore irrelevant details like headlights or wheels to focus exclusively on variables that affect the specific problem, such as velocity. The incorrect options completely misrepresent the primary purpose of scientific modeling.

43. How does the philosophically describe the strict divisions of natural science into specialized branches like physics, chemistry, biology, and earth science?
- (A) Nature itself created these rigid permanent boundaries universally.
 (B) These rigid boundaries ensure disciplines remain entirely independent and isolated.
 (C) These divisions are artificial constructs made merely to help systematically organise human knowledge.
 (D) Earth science strictly forbids utilizing any mathematical principles whatsoever.

Ans : (C)

The natural world naturally functions as a unified whole, possessing absolutely no inherent rigid boundaries. Humans artificially created distinct specialized branches—like physics and biology—strictly as convenient organisational tools to help systematically categorize vast knowledge. Ultimately, heavily resolving complex real-world problems urgently requires seamlessly combining profound ideas from all these interconnected disciplines simultaneously.

44. **Assertion (A):** Developing sustainable global technologies fundamentally requires seamlessly integrating profound ideas from multiple different scientific disciplines together.

Reason (R): The complex natural environment strictly compartmentalizes its functions into entirely separate, isolated biological and chemical boundaries.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

The assertion is completely true; solving massive real-world problems fundamentally demands seamlessly merging knowledge across physics, biology, and more. However, the reason is fundamentally false. The natural environment operates holistically and does absolutely not compartmentalize functions. Humans artificially invented these disciplinary boundaries solely for academic convenience, but complex nature inherently completely ignores such artificial human-made distinctions.

45. Match the specific scientific discipline in List-I strictly with its practical functional application in designing a safety mask from List-II.

List-I (Discipline)

- P. Physics
 Q. Chemistry
 R. Biology
 S. Mathematics

List-II (Application)

1. Understanding properties of polymer fibres
2. Modelling airflow and overall filtration efficiency
3. Analysing particle motion and electrostatic attraction

4. Studying the physical size and behaviour of microscopic viruses
 (A) P-3, Q-1, R-4, S-2
 (B) P-1, Q-3, R-2, S-4
 (C) P-4, Q-2, R-1, S-3
 (D) P-3, Q-4, R-1, S-2

Ans : (A)

Designing an effective protective mask brilliantly requires deeply interconnected multidisciplinary knowledge. Physics strictly handles crucial particle motion and necessary electrostatic attraction (P-3). Chemistry primarily deals with the complex material properties of specialized polymer fibres (Q-1). Biology fundamentally studies the exact microscopic size and infectious behaviour of dangerous viruses (R-4). Finally, Mathematics rigorously models complex airflow dynamics (S-2).

46. Consider the following statements regarding the overarching fundamental nature of scientific endeavour:
1. Science is merely a static, unchangeable collection of rigid historical facts.
 2. Science dynamically grows strictly through widespread curiosity, boundless creativity, and careful collaborative questioning.
 3. Science heavily develops over time directly through the dedicated work of countless individuals across varied cultures.
 4. Robust scientific thinking profoundly helps individuals critically evaluate surrounding daily information.

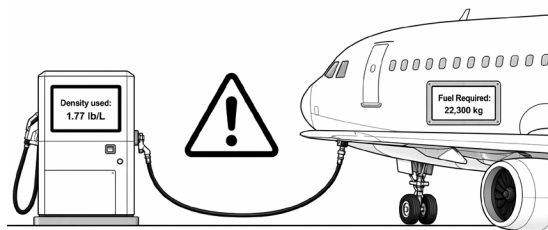
Which combination of statements accurately reflects the chapter's conclusion?

- (A) 1, 2, and 3
 (B) 2, 3, and 4
 (C) 1, 3, and 4
 (D) 1, 2, and 4

Ans : (B)

Statements 2, 3, and 4 deeply reflect the textbook's profound concluding philosophy. Science is definitively a deeply collaborative, intensely creative human activity universally transcending diverse cultures, actively empowering critical thinking far beyond mere classrooms. Conversely, statement 1 is completely false because science is actively dynamic and constantly evolving, certainly not a lifeless, static collection of rigid historical facts.

47. Based on the scenario depicted in the diagram, what is the primary cause of the potential error indicated by the central warning symbol?



- (A) The physical properties of the fuel change when transferred from the pump to the airplane.
 (B) The calculations rely on non-standardized local opinions rather than scientific evidence.
 (C) The mathematical equations used are fundamentally incorrect for calculating fuel volume.
 (D) The quantities are expressed in inconsistent units, preventing accurate scientific calculation.

Ans : (D)

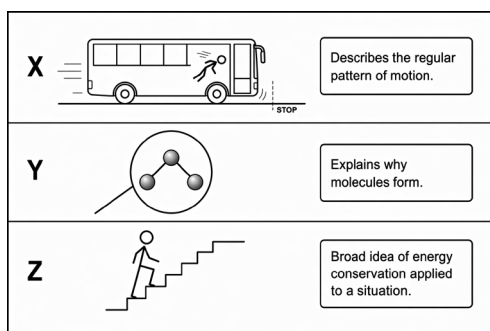
The diagram highlights fuel density in pounds per litre but fuel required in kilograms. Mixing different unit systems leads to dangerous calculation errors. Standard SI units act as a universal shared language, ensuring that scientific measurements and everyday calculations remain consistent, comparable, and entirely free from avoidable conversion mistakes across different regions.

48. Arrange the following critical sequential steps to correctly reflect the fundamental process of building strong scientific understanding as implied throughout the chapter.
1. Formulating reasoned expectations or predictions.
 2. Building simplified models to strictly focus on essential details.
 3. Engaging in careful observation and boundless curiosity.
 4. Rigorously testing ideas and thoroughly revising models based on fresh evidence.
- (A) 3 -> 2 -> 1 -> 4
 (B) 2 -> 3 -> 4 -> 1
 (C) 3 -> 1 -> 2 -> 4
 (D) 1 -> 4 -> 3 -> 2

Ans : (A)

The logical scientific journey essentially begins with intense curiosity and careful, meticulous observation (3). To practically handle overwhelming natural complexity, scientists first deliberately construct highly simplified models (2). Utilizing these established models, they systematically generate logical, reasoned predictions regarding future outcomes (1). Finally, they relentlessly test these specific predictions and meticulously revise their ideas using new evidence (4).

49. How should the scientific terms be correctly mapped to the core concepts represented by X, Y, and Z in the diagram?



- (A) X - Theory, Y - Principle, Z - Law
 (B) X - Law, Y - Theory, Z - Principle
 (C) X - Principle, Y - Law, Z - Theory
 (D) X - Theory, Y - Law, Z - Principle

Ans : (B)

In science, a 'Law' (X) describes a regular pattern observed in nature, like the laws of motion. A 'Theory' (Y) provides an explanation for why these patterns occur, such as atomic theory explaining molecular structures. A 'Principle' (Z) is a broad over arching idea, like the conservation of energy, applied to make sense of given situations.

50. To systematically evaluate complex problems beyond the classroom using robust scientific habits, the textbook strongly recommends a highly specific logical sequence. Identify the strictly correct order of these critical initial thinking steps.
- (A) Immediately calculate precisely -> Identify quantities -> Ignore assumptions entirely
 (B) First understand the situation thoroughly -> Identify important quantities -> Make a rough approximate estimate
 (C) Guess randomly -> Memorise equations -> Calculate to five decimal places
 (D) Ignore quantities entirely -> Rely purely on intuition -> Abandon mathematical calculations

Ans : (B)

To profoundly develop robust scientific thinking habits heavily applicable in complex daily life, the textbook emphatically prescribes a highly practical, sequential logical strategy. One must initially strive to completely understand the underlying situation fundamentally, then carefully identify only the most vital quantities involved, and logically conclude by making a rough, approximate estimate to systematically verify overall reasonableness.

51. Consider the following crucial statements regarding the use of advanced mathematical expressions in fundamental science:

1. They essentially operate as highly compact, intensely precise logical statements detailing exactly how distinct physical quantities are fundamentally related.
2. They drastically hinder critical reasoning by forcing unnecessary, overly complex calculations.
3. They profoundly allow scientists to effectively predict where a moving object will be accurately located at a later moment.

Which specific statements are factually correct according to the chapter?

- (A) 1 and 2 only
 (B) 2 and 3 only
 (C) 1 and 3 only
 (D) 1, 2, and 3

Ans : (C)

Mathematics provides an incredibly powerful, deeply expressive shared language for science. Equations act as remarkably compact, highly precise logical statements strictly defining complex physical relationships (Statement 1). This mathematical precision inherently allows scientists to reliably predict future dynamic physical states accurately (Statement 3). Conversely, Statement 2 is entirely incorrect because mathematics fundamentally enhances—not hinders—deep logical reasoning.

52. Consider the following detailed statements concerning physicist Meghnad Saha's brilliant theoretical modelling of stars:

1. He completely ignored highly complex microscopic atomic processes.
2. He meticulously modelled every single chemical reaction occurring rapidly inside the massive star.

3. He focused intensely and exclusively on broader thermodynamic factors like extreme temperature and high pressure.
4. His deliberate theoretical simplification successfully allowed him to physically explain exactly how the vibrant colour of stars is deeply connected to their surface temperature.

Which specific combination correctly identifies true statements?

- (A) 1, 2, and 3
- (B) 1, 3, and 4
- (C) 2, 3, and 4
- (D) 1, 2, and 4

Ans : (B)

Meghnad Saha's incredible theoretical success directly relied on deliberate, extreme simplification. He purposefully ignored tracking overwhelmingly complex individual atomic reactions (Statement 1 is true, directly making Statement 2 false). Instead, he focused entirely on macroscopic thermodynamic properties like temperature and pressure (Statement 3), successfully enabling him to brilliantly physically link stellar colour directly to exact stellar temperatures (Statement 4).

- 53. Assertion (A):** An effectively simple, functional mathematical model predicting whether a struck cricket ball successfully crosses the boundary line absolutely does not include the brand name of the bat.

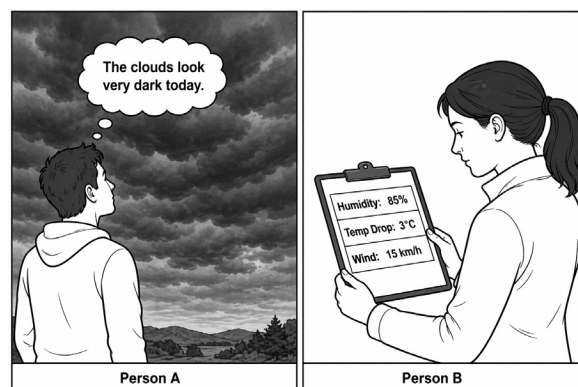
Reason (R): The specific brand name of the bat has absolutely zero physical effect on the fundamental aerodynamic trajectory and final distance travelled by the flying ball.

- (A) Both A and R are true and R is the correct explanation of A
- (B) Both A and R are true but R is not the correct explanation of A
- (C) A is true but R is false
- (D) A is false but R is true

Ans : (A)

The assertion perfectly describes proper scientific modelling methodology. A functional boundary-predicting model selectively includes only essential physical parameters like velocity and mass. The provided reason perfectly explains why: entirely aesthetic, non-physical details like bat branding exert absolutely zero mechanical force or aerodynamic influence on the flying ball, thus completely justifying their deliberate, necessary exclusion from the calculation.

- 54.** Why is Person B's approach considered a more scientifically testable prediction than Person A's approach?



- (A) Person B relies on undeniable proof that guarantees a correct outcome regardless of changing factors.
- (B) Person B uses measurable data and past patterns rather than subjective visual opinions.
- (C) Person B has formulated a complete scientific theory about the complex mechanisms of cloud formation.
- (D) Person B is applying an exact mathematical equation to find a definitive numerical answer.

Ans : (B)

Scientific predictions are reasoned expectations based on evidence, not mere guesswork. Person A relies on a subjective visual observation, while Person B uses past measurable parameters like humidity, temperature, and wind speed. Scientifically testable questions look for quantifiable data and historical patterns rather than relying on unmeasured visual appearances, making subjective options incorrect.

- 55. Assertion (A):** Newton's highly famous descriptions detailing the precise physical jerk experienced uniformly when a moving bus abruptly stops are strictly scientifically classified as "Theories".

Reason (R): In science, a "Law" simply describes a highly regular, remarkably predictable physical pattern observed persistently in nature, often expressed using words or math.

- (A) Both A and R are true and R is the correct explanation of A
- (B) Both A and R are true but R is not the correct explanation of A

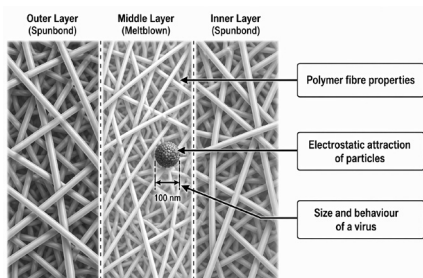
(C) A is true but R is false

(D) A is false but R is true

Ans : (D)

The assertion is factually incorrect because Newton's descriptions of physical motion are universally classified strictly as scientific "Laws", not as "Theories". However, the reason provided is entirely correct. A scientific law precisely describes a consistent, mathematically predictable pattern directly observed repeatedly in nature, definitively stating what persistently happens without necessarily attempting to deeply explain exactly why it happens.

56. What core characteristic of scientific study is best demonstrated by the integrated mechanisms shown in the diagram of the mask?



- (A) Scientific disciplines operate independently with strict boundaries separating distinct subjects.
 (B) Real-world problems require integrating concepts from chemistry, physics, and biology together.
 (C) Scientific models are only useful when they are represented by exact mathematical equations.
 (D) Complex technologies can only be understood by isolating and studying one specific branch of science.

Ans : (B)

The natural world lacks strict boundaries between scientific branches. Understanding how a protective mask functions requires combining chemistry for polymer properties, physics for electrostatic attraction, and biology to understand virus sizes. This demonstrates that solving real-world problems depends on connecting multiple disciplines simultaneously, proving that rigid subject boundaries are artificial and restrictive.

57. Carefully arrange the following foundational scientific concepts in the precise chronological sequence they are primarily introduced and conceptually explored.

1. The profound importance of deliberately simplifying incredibly complex reality by creating models.
2. Utilizing mathematics as a powerful, remarkably compact shared conceptual language in strict scientific inquiry.
3. The vital conceptual distinction between strictly descriptive laws and deeply explanatory theories.
4. The immense practical value of performing rough approximate estimations to quickly build physical intuition.

(A) 1 -> 2 -> 3 -> 4

(B) 2 -> 1 -> 4 -> 3

(C) 4 -> 3 -> 2 -> 1

(D) 3 -> 1 -> 2 -> 4

Ans : (A)

Following the chapter's precise structural progression: The text intentionally first introduces building simplified models to manage natural complexity (1). It then extensively discusses shared symbols and mathematics as science's core language (2). Subsequently, it formally defines the precise conceptual differences between descriptive laws, profound theories, and broad principles (3). Finally, it practically concludes by heavily teaching valuable rough estimation skills (4).

58. Identify the distinctly INCORRECT statement deeply regarding the fundamental nature of mathematics within the strict context of modern scientific study.

- (A) Mathematics provides deeply compact logical statements perfectly defining complex relationships.
 (B) Mathematics fundamentally helps brilliant scientists think much more clearly about real-world phenomena.
 (C) Mathematics acts as a completely insurmountable hurdle intentionally designed to drastically confuse young secondary students.
 (D) Mathematics serves as a remarkably powerful universal language inherently designed for careful logical reasoning.

Ans : (C)

The textbook emphatically, explicitly clarifies that mathematics is definitely not meant to operate

as an intensely confusing hurdle or intimidating obstacle for growing students. Instead, it powerfully functions as a profoundly helpful, incredibly compact universal scientific language. Mathematics fundamentally enables clearer, highly logical critical thinking and shamelessly expresses intricate, deeply vital physical relationships clearly without overwhelming verbal complexity.

59. Which highly specific combination of fundamental scientific principles is most critically essential when actively attempting to successfully predict exactly how soft a newly baked loaf of bread would practically turn out?
- (A) Primarily relying on advanced astronomical and deep geological principles
 - (B) Heavily utilizing strictly biological and complex chemical principles
 - (C) Exclusively applying rigid Newtonian mechanical physics and quantum mathematics
 - (D) Relying entirely on random guesswork completely void of empirical observation

Ans : (B)

Accurately predicting the final physical softness of baked bread essentially demands heavily integrating knowledge from multiple disciplines. One must fundamentally utilize biological principles to properly understand active yeast fermentation processes. Simultaneously, one must strictly apply complex chemical principles to fully comprehend the intricate molecular reactions involving heat, gluten formation, and gas expansion occurring dynamically inside the baking oven.

60. Which of the following absolutely does NOT represent a valid, legitimate reason why working scientists heavily rely on mathematical equations during rigorous modern research?
- (A) To strictly identify and quantify highly relevant physical quantities seamlessly.
 - (B) To logically determine precisely where a fast-moving physical object will eventually be located.
 - (C) To mindlessly memorize arbitrary, completely disconnected abstract numbers devoid of deep conceptual meaning.
 - (D) To powerfully describe incredibly intricate, highly complex patterns underlying rapid population growth.

Ans : (C)

Scientists absolutely do not utilize complex mathematical equations simply to mindlessly memorize seemingly arbitrary, disconnected abstract numerical values. Rather, advanced mathematics fundamentally serves as an exceptionally powerful, highly compact descriptive language deeply necessary for clear reasoning. It allows researchers to seamlessly calculate physical trajectories, rigorously identify highly relevant variables, and logically quantify complex, dynamic natural patterns extremely effectively.

61. Complete the following deep conceptual relationship directly based entirely on exact textbook definitions.
- The incredibly robust Atomic theory : Fundamentally perfectly explains exactly how unseen molecules are complexly formed :: The broad Principle of energy conservation : ?
- (A) Describes the exact mathematical speed of incoming solar starlight.
 - (B) Describes the rigid physical jerk violently felt when a bus abruptly halts.
 - (C) Proves absolutely that dangerous eclipses severely logically poison human food.
 - (D) Broadly helps humans systematically make deep logical sense of situations like climbing steep stairs.

Ans : (D)

This detailed scientific analogy meticulously contrasts specific textbook conceptual definitions. Just as the powerful atomic theory provides a profound microscopic explanation detailing precisely how molecular bonding occurs, the broad macroscopic principle of energy conservation provides an overarching logical framework strictly helping us effortlessly comprehend practical daily physical phenomena, such as the intense physical exertion practically required while actively climbing stairs.

VERY SHORT ANSWER

62. What do the magnifying glass and compass symbolise in the design of this textbook?

Ans :

The magnifying glass symbolizes careful observation and noticing patterns, while the compass represents needing direction, choosing appropriate models, and asking the right questions.

- 63.** What does the study of science in the secondary stage heavily emphasise beyond just knowing basic facts?

Ans :

It emphasises deep exploration, focusing on how observations lead to measurements, how models are built, and how ideas are carefully tested and revised.

- 64.** Why do scientists consistently use simplified models to study the highly complex natural world?

Ans :

Scientists use simplified models to deliberately ignore certain details, focusing only on the most important factors needed to answer a specific scientific question.

- 65.** Give one example of how a complex entity is simplified into a model in the field of chemistry.

Ans :

In chemistry, complex atoms and molecules are often represented simply as drawn spheres and connecting bonds to help scientists focus on their interactions.

- 66.** How did physicist Meghnad Saha successfully simplify the highly complex matter inside a star to study its light?

Ans :

He simplified the star by treating its matter as a hot gas, focusing only on temperature, pressure, and ion formation while ignoring other processes.

- 67.** Which specific details can be safely ignored when making a simple model of a cricket ball being hit for a six?

Ans :

Minor details like the brand of the bat, the colour of the ball, or the amount of grass on the field can be ignored.

- 68.** Why do scientific terms like force, work, or cell have very specific and precise meanings in textbooks?

Ans :

They have precise meanings so that scientific ideas can be communicated clearly and unambiguously among scientists across the world to build ideas together.

- 69.** What is the primary role of mathematics when studying complex systems in secondary stage science?

Ans :

Mathematics serves as a powerful language for clear thinking, helping us understand situations and accurately express relationships between different quantities through compact equations.

- 70.** Why is the universal speed of light universally denoted by the specific symbol 'c' in scientific equations?

Ans :

It is denoted by 'c' based on historical international agreements, originating from the Latin word 'celeritas', which translates to speed in the English language.

- 71.** What was the major consequence of the ground crew mixing up pounds and kilograms in the airplane fuel miscalculation?

Ans :

The aircraft received drastically less fuel than actually required, causing it to run completely out of fuel mid-flight and forcing a dangerous emergency landing.

- 72.** Why is it absolutely necessary for scientists to use agreed international standard units for measurements everywhere?

Ans :

Standard units prevent dangerous confusion, allow scientific results to be easily compared globally, and ensure fairness in daily life activities like trade and commerce.

- 73.** How is a scientific law accurately defined in the context of organising our understanding of the natural world?

Ans :

A scientific law usually describes a regular, predictable pattern observed in nature, which is often clearly expressed using words or precise mathematical relationships.

- 74.** State one major difference between a scientific law and a scientific theory based on how they handle patterns.

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Ans :

A law describes a regular pattern observed in nature, whereas a theory goes further by providing an evidence-based explanation for why those patterns occur.

- 75.** Give one example of a broad scientific principle that successfully helps us make sense of specific physical situations.

Ans :

The principle of conservation of energy is a broad scientific idea that helps us understand specific physical situations, like the effort of climbing stairs.

- 76.** What does the term ‘theory’ actually mean in science, completely contrary to its normal everyday usage?

Ans :

In science, a theory does not mean a mere guess; it is a well-reasoned explanation based on careful testing and evidence gathered over time.

- 77.** Why is the ability to make precise predictions considered one of the most remarkable strengths of scientific thinking?

Ans :

Predictions allow scientists to anticipate what will happen under new conditions before experimenting, and matching observations build confidence in the underlying scientific ideas.

- 78.** What primarily causes professional weather forecasts to sometimes become highly unreliable further into the future?

Ans :

Forecasts become unreliable because very tiny differences in initial conditions can grow significantly over time, eventually leading to completely different and unpredictable weather outcomes.

- 79.** How does science generally respond when well-established predictions completely fail to match precise new measurements?

Ans :

Such failures are viewed as a great strength, prompting scientists to openly re-examine their assumptions and correct theories based purely on new factual evidence.

- 80.** How can basic scientific questioning completely disprove the viral claim that eating food during a solar eclipse is harmful?

Ans :

Simple questions reveal an eclipse is merely a shadow, lacking any chemical or biological mechanism that could suddenly cause everyday food to become harmful.

- 81.** What is the primary advantage of making an approximate estimate before performing highly accurate scientific calculations?

Ans :

An approximate estimate quickly reveals if a result is reasonable, helping build intuition and detect errors before relying on perfectly accurate mathematical calculations.

- 82.** How can one quickly estimate the daily kilocalorie requirement of an average human adult using basic scientific reasoning?

Ans :

An accurate daily estimation can be logically made by assuming that an average human adult typically requires about 2000 to 2500 kilocalories of energy.

- 83.** Under what condition might it be better to use rough estimation instead of finding a perfectly exact mathematical answer?

Ans :

Rough estimation is best used in the early stages of reasoning to quickly check if an answer makes practical sense for everyday scientific questions.

What is the relationship between different scientific branches like physics, chemistry, and biology in the real natural world?

Ans :

The natural world lacks strict boundaries; these divisions are merely human-made constructs designed to help logically organise and simplify our rapidly expanding scientific knowledge.

- 85.** Why is it strictly necessary to connect multiple branches of science to solve modern real-world problems like climate change?

Ans :

Solving complex real-world problems requires integrating knowledge from diverse disciplines

like physics, chemistry, biology, and mathematics because these interconnected fields deeply enrich one another.

86. How do principles of physics and chemistry specifically contribute to the effective functioning of a surgical safety mask?

Ans :

Physics explains crucial concepts like particle motion and electrostatic attraction, while chemistry provides necessary knowledge about the specific properties of the mask's polymer fibres.

87. Give one reason why scientific thinking remains highly important even for students who completely abandon science after Grade 10.

Ans :

Scientific thinking helps individuals critically evaluate surrounding information and deeply understand the complex everyday technologies that constantly shape the modern world they live in.

88. What is science fundamentally described as, far beyond just being a mere collection of facts, equations, and experiments?

Ans :

Science is fundamentally a dynamic human activity that is deeply shaped by continuous curiosity, creativity, collaboration, and careful questioning by people across different cultures.

89. Describe exactly how the human heart is treated as a functioning system when creating a highly simplified biological model.

Ans :

When studying how blood is pumped, scientists deliberately ignore many individual cells so the organ can be practically understood as a single functioning system.

90. What vital realization did scientists make regarding how science grows beyond its initial beginnings of very simple wonder?

Ans :

They discovered that while science initially begins with a simple sense of wonder, it primarily grows and develops further through the execution of careful experiments.

91. How does the global scientific community generally handle the inevitable mistakes and experimental failures made during ongoing scientific research?

Ans :

Scientists openly share results and actively learn from mistakes, using them to continuously test ideas and effectively refine their understanding of the natural world.

SHORT ANSWER QUESTIONS

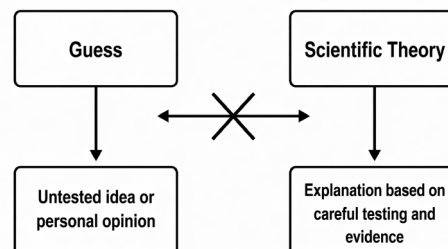
92. Explain why scientists use models to study the natural world, giving an example from the chapter.

Ans :

Scientists use models because the natural world is highly complex and studying it in full detail is often impossible. Models are simplified ways of looking at real systems that focus only on the most important factors for a given question while deliberately ignoring certain details. For example, when studying a falling object, air resistance might be ignored to focus on gravity's basic effect. This simplification keeps things manageable and allows scientists to find clear answers to specific questions without being overwhelmed by unnecessary complexities.

93. Draw a simple comparative flowchart showing how a scientific theory differs from a guess. Explain this difference based on the chapter.

Ans :



In science, a theory is not simply a guess or an untested idea. While a guess might be based on intuition or opinion, a scientific theory provides a robust explanation of why regular patterns occur in nature. This explanation is deeply rooted in evidence gathered over time and is subject to

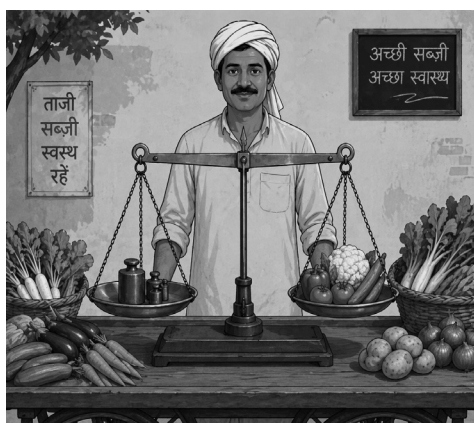
careful testing and critical examination. Unlike a mere guess, theories are widely accepted based on available facts but remain open to improvement and change as new evidence is continuously discovered through rigorous scientific exploration.

94. What is the significance of using specific scientific symbols and standard units? How did a mix-up in units cause an airplane incident?

Ans :

Scientific symbols and standard units, like the SI system, are crucial because they provide a precise and universally shared language. This allows scientists globally to describe observations clearly, compare results accurately, and build ideas together without ambiguity. A well-known airplane incident occurred when ground crew miscalculated fuel, using pounds per litre instead of kilograms per litre. The aircraft ran out of fuel mid-flight because pounds and kilograms represent very different masses. Standard units prevent such dangerous conversions and errors in science and daily life.

95. Study the given diagram of a vegetable seller using a pan balance. Why is a standard unit like the kilogram essential for this daily life activity? What would happen without it?



Ans :

A standard unit like the kilogram is essential in daily life activities, such as buying vegetables, because it guarantees that a specific measurement means the exact same amount everywhere. These measurements are based on agreed international standards rather than local objects or personal opinions. If we did not have standard units, widespread confusion would occur in everyday trade. Using different, unstandardized weights in

different locations would make it impossible to compare quantities fairly, leading to commercial disputes and inconsistency across different regions.

96. A student claims that a scientific theory is absolute and can never be changed once it is established. Do you agree? Justify your answer.

Ans :

I completely disagree with this claim. No scientific theory is ever considered absolutely final, and none is beyond critical questioning. A key feature of science is its openness to being corrected by nature itself. Theories are established explanations based on current evidence, but they are always open to improvement. When new conditions are explored or measurements become more precise, even successful theories might fail or require modification. Therefore, theories frequently change and evolve as new evidence becomes available, which is actually science's greatest strength.

97. Compare a scientific law and a scientific theory based on their fundamental roles in understanding nature.

Ans :

A scientific law and a scientific theory serve different but complementary roles in science. A scientific law usually describes a regular, observable pattern in nature, often expressed through words or exact mathematical relationships. For example, Newton's laws of motion describe the predictable physical behavior of objects. In contrast, a scientific theory goes a step further by providing a comprehensive explanation of why those specific patterns occur. While laws describe what happens under certain conditions, theories explain the underlying mechanisms based on extensive evidence and careful testing.

98. Explain how physicist Meghnad Saha used scientific modelling to understand the nature of stars.

Ans :

Physicist Meghnad Saha successfully simplified the incredibly complex nature of stars through scientific modelling. He did not attempt to model every single atom, every chemical reaction, or every movement occurring inside a star, as that would be impossible. Instead, he treated the matter inside the star simply as a hot gas. By

ignoring many complex processes and focusing solely on fundamental properties like temperature and pressure, his simplified model brilliantly explained how the unique colour of stars is deeply connected to their varying temperatures.

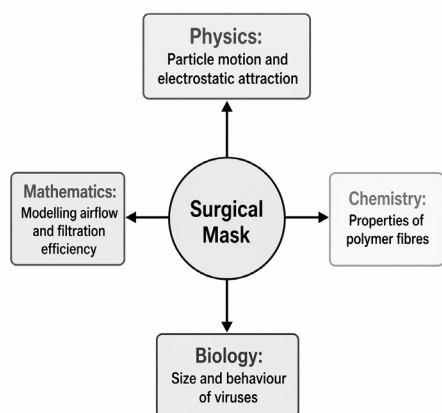
99. How is mathematics used as a powerful language in science? Give an example to support your answer.

Ans :

In science, mathematics is not just a calculation tool but a highly compact and precise language used to express how certain quantities relate to each other. It helps scientists think more clearly and reason carefully about the natural world. For instance, using an equation with variables like distance, time, and velocity allows scientists to predict exactly where a moving object will be at a later moment. Mathematical expressions beautifully describe population growth patterns, chemical reaction rates, and energy changes within complex biological or physical systems.

100. Draw a simple representation showing the interdisciplinary nature of science using the example of a surgical mask. Why is it important to connect multiple branches of science?

Ans :



Solving complex real-world problems requires connecting multiple branches of science because nature does not have strict subject boundaries. As seen in the design of safety masks, understanding how they work involves physics for electrostatic attraction, chemistry for polymer fibre properties, biology for understanding virus behaviour, and mathematics for modelling airflow. Most modern

challenges, like climate change or sustainable technology development, cannot be solved independently. Connecting various scientific disciplines enriches our overall understanding and provides comprehensive solutions to intricately connected real-world problems.

101. Describe the importance of making approximations or rough estimates in early scientific reasoning.

Ans :

Making approximations or rough estimates is a crucial skill in the early stages of scientific reasoning because it helps build intuition and detect errors. Exact calculations are not always necessary to evaluate a situation. An approximate estimate is often sufficient to tell scientists whether a result is scientifically reasonable or entirely impossible. For example, estimating the daily calorie requirement of a family can quickly reveal if a calculated food resource amount makes sense. This practice develops strong confidence in critical thinking and everyday scientific problem-solving.

102. Explain the scientific reason why a commonly circulated social media claim about food becoming harmful during a solar eclipse is invalid.

Ans :

The claim that food becomes harmful during a solar eclipse is scientifically invalid because it lacks any supporting physical, chemical, or biological mechanism. Critical scientific questioning reveals that a solar eclipse is merely a simple play of shadows created by celestial bodies. The physical environment does not drastically alter, temperatures do not change significantly enough to spoil food, and food left in a shadow does not inherently turn bad. Disproof comes from recognizing that observations do not support this unfounded belief or opinion.

103. What are scientific predictions? Why are they considered a powerful tool that drives further exploration?

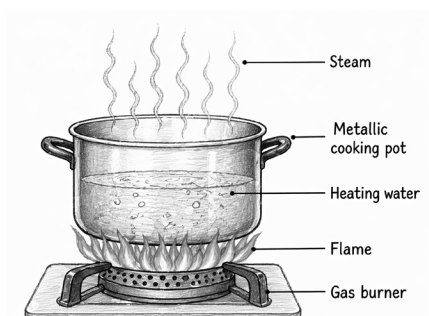
Ans :

Scientific predictions are reasoned expectations about what will happen under new or different conditions, based entirely on current evidence, established principles, and careful thinking. They are not random guesses. Predictions are a powerful tool because they allow scientists to anticipate

outcomes before performing an experiment. When observations consistently match these predictions, confidence in the underlying scientific theories grows stronger. Even more importantly, when predictions do not match real-world observations, they force scientists to re-examine their assumptions and models, driving deeper exploration and understanding.

- 104.** Draw a simple labelled setup showing how water is heated for everyday use. Explain how this simple activity connects to scientific principles.

Ans :



Heating water on a stove directly connects everyday activities to fundamental scientific principles. The burning of the cooking gas involves a chemical reaction that releases thermal energy. This energy transfers into the metallic pot and then into the water, illustrating physical concepts of heat transfer and energy conservation. As the water temperature rises, its physical state eventually changes, producing steam. By carefully observing such daily routines, we begin to appreciate how principles of chemistry and physics govern the natural and technological world around us.

- 105.** What constitutes a scientifically testable prediction? How can Varsha use past data to accurately predict if it will rain today?

Ans :

A scientifically testable prediction is a reasoned expectation based entirely on measurable evidence and careful thinking rather than simple guesswork. To predict if it will rain, Varsha must move beyond simple observations like looking at dark clouds. She needs to ask specific questions about measurable environmental data, such as current humidity, wind speed, and temperature changes. By carefully comparing today's specific numerical data with established past weather

patterns—like the humidity level during the last rain—she can formulate a highly reliable and scientifically sound prediction.

- 106.** Define a scientific theory. Why is it absolutely essential that theories remain constantly open to critical examination?

Ans :

A scientific theory is a well-established explanation of why regular patterns occur in nature, constructed solidly upon evidence gathered over time through careful testing. However, it is essential that theories remain open to continuous critical examination because science constantly evolves. As new environmental conditions are explored or experimental measurements become significantly more precise, older theories may fail or require major adjustments. This openness to being corrected by new observable evidence is precisely what allows scientific knowledge to continually improve and accurately reflect reality.

- 107.** Explain why weather forecasts are usually reliable for a short time but become much less certain further into the future.

Ans :

Weather forecasts rely on many constantly changing factors, such as temperature, atmospheric pressure, humidity, and wind patterns. Meteorologists use precise measurements and complex mathematical models to predict weather based on these variables. However, weather systems are highly sensitive. Even very tiny initial differences in these conditions can grow significantly over time, leading to completely different outcomes. Therefore, while forecasts are usually quite reliable for a few hours or a couple of days, this compounding unpredictability makes them much less certain further into the distant future.

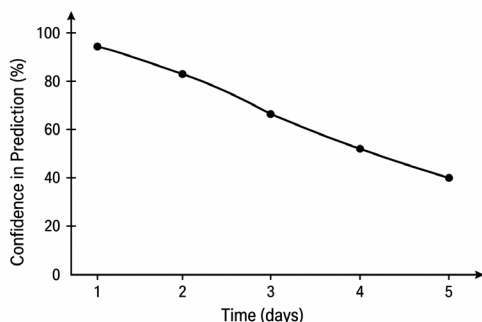
- 108.** Your friend claims that if a scientific model deliberately ignores certain details, it must be considered a mistake or a flawed model. Do you agree? Explain.

Ans :

I disagree with this claim. In science, deliberately ignoring certain details is not a mistake but a highly necessary technique for building effective models. The real world is incredibly complex, making it impossible to study every single variable at once. By neglecting minor factors—such as ignoring air

resistance to study the basic gravity of a falling object—scientists can keep things simple enough to analyze clearly. These intentional simplifications allow researchers to find direct answers to specific fundamental questions without being hindered by unnecessary complexities.

109. Study the given graphical representation.



Based on this graph and the chapter, why does confidence in weather predictions drop rapidly over time?

Ans :

The graph illustrates that our confidence in predicting weather heavily decreases as we look further into the future. Weather fundamentally depends on dynamic, ever-changing factors like temperature, pressure, and wind. Predictive models use current measurements to forecast these changes. However, even the most microscopic errors or variations in today's data will multiply and grow significantly over several days. This rapid growth of tiny differences in initial conditions eventually leads to entirely different weather patterns, making long-term predictions represented on the graph highly uncertain and less reliable.

110. Compare how physics and biology might use simplified models differently when studying their respective complex natural systems.

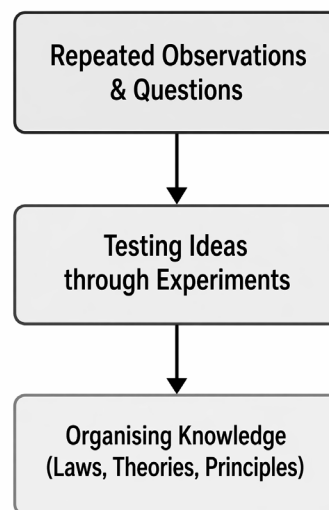
Ans :

Physics and biology both use simplified models, but they apply them differently based on their specific needs. In physics, complex objects are often reduced to their most basic mathematical forms; for instance, a large moving car might be represented simply as a single geometric point to calculate its velocity or momentum easily. In contrast, biology uses structural diagrams to highlight key anatomical parts. When studying how a heart pumps blood, biological models may

deliberately ignore billions of individual cells so the organ functions can be understood holistically.

111. Draw a simple flowchart illustrating the concept of a “systematic way” of organizing science. How does science build upon repeated observations?

Ans :



Science organizes our understanding of the world in a highly systematic way. It begins with curiosity and making careful, repeated observations about the natural environment. These observations naturally lead to specific questions and the formulation of testable ideas. Scientists then rigorously test these ideas through controlled experiments. As experiments continuously validate or refine these concepts, the resulting knowledge is formally organized into structured laws, theories, and principles. This progressive, evidence-based method ensures that scientific knowledge continuously grows, adapts, and accurately reflects the physical universe.

112. Explain why the speed of light is denoted by the specific symbol ‘c’ and how this relates to the origin of scientific symbols.

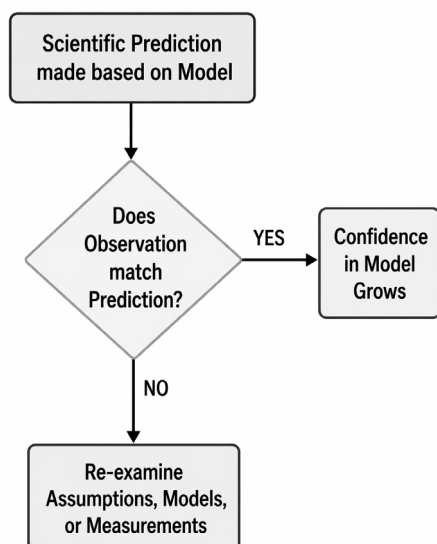
Ans :

The speed of light is denoted by the symbol ‘c’ due to its historical linguistic roots, specifically derived from the Latin word “celeritas,” which translates to meaning speed or swiftness. Scientific symbols are often chosen based on historical context and established through international agreements for universal consistency. They are not necessarily just simple abbreviations of modern English words.

Today, the speed of light ‘c’ is recognized globally as one of the fundamental physical constants, specifically defined to be exactly 299,792,458 metres per second in scientific literature.

113. Draw a simple flowchart showing what happens when a scientific prediction fails. Explain how this failure is actually a strength of science.

Ans :



When a scientific prediction fails, it is not a weakness but actually one of science's greatest strengths. A failed prediction forces scientists to pause and carefully re-examine their initial assumptions, experimental models, or measurement techniques. Because science does not reject ideas based on personal opinion but strictly on observable evidence, recognizing a failure naturally drives further detailed exploration. This critical openness to being corrected by nature itself continuously refines our theories, ultimately leading to a much deeper and more accurate understanding of the real world.

114. Explain why the speed of light is denoted by the specific symbol ‘c’ and how this relates to the origin of scientific symbols.

Ans :

The speed of light is denoted by the symbol ‘c’ due to its historical linguistic roots, specifically derived from the Latin word “celeritas,” which translates to meaning speed or swiftness. Scientific symbols are often chosen based on historical context and established through international agreements for universal consistency. They are not necessarily just

simple abbreviations of modern English words. Today, the speed of light ‘c’ is recognized globally as one of the fundamental physical constants, specifically defined to be exactly 299,792,458 metres per second in scientific literature.

115. Explain the logical process of estimating the total volume of air a person breathes in one single day, as described in the chapter.

Ans :

To estimate the daily air volume breathed, we first calculate total breaths. At roughly 12 to 15 breaths a minute, multiplying by minutes in a day yields about 18,000 to 22,000 breaths daily. Next, we estimate the volume of a single breath by comparing it to inflating a balloon. If 4 to 5 breaths fill a two-litre balloon, one breath is approximately 0.5 litres. Finally, multiplying the 20,000 daily breaths by the 0.5-litre average volume provides a reasonable approximation of roughly 10,000 litres of air breathed daily.

116. What exactly is a scientific principle? How does a principle differ significantly from a specific mathematical equation?

Ans :

A scientific principle is a broad, overarching idea or concept that helps scientists make sense of a given situation in nature. For example, the principle of conservation of energy explains how energy transforms when a person climbs stairs. In contrast, a specific mathematical equation is a compact, precise statement showing exactly how certain measurable quantities relate to each other numerically. While an equation provides the exact mathematical calculation for a specific event, a principle provides the fundamental, guiding conceptual rule that governs those broad physical interactions.

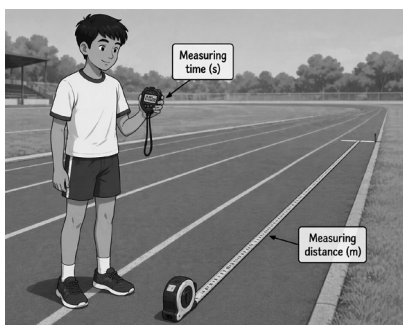
117. Describe the deeper scientific meaning behind the magnifying glass and the compass used as framing symbols for the textbook's page numbers.

Ans :

The textbook uses a magnifying glass and a compass as framing symbols to reflect the true approach of scientific exploration. The magnifying glass symbolises careful observation—paying close attention to subtle patterns and noticing intricate details that might otherwise be easily missed. Meanwhile, the compass reminds us that exploration requires direction; we must choose appropriate

models, ask the right questions, and carefully know the limits of our ideas. Together, they signify that science is not aimless wandering, but a purposeful, evidence-based attempt to understand the world.

118. Study the given diagram of a student measuring time with a stopwatch and distance with a tape measure.



Why is it critically important to use specific SI units like seconds and metres when communicating these measurements?

Ans :

It is vitally important to use specific terms and standard SI units, such as seconds for time and metres for distance, to ensure completely clear and unambiguous scientific communication. When a student records data using these universally agreed-upon standards, any scientist around the world can understand, compare, and verify the results accurately. If local or non-standard units were used instead, it would cause widespread confusion and severe calculation errors. Standardized units allow researchers to build upon each other's work reliably and maintain consistency in global scientific research.

119. Describe the proper sequence of steps involved in evaluating an everyday problem scientifically, according to the textbook's helpful strategy.

Ans :

When evaluating a problem scientifically, the first crucial step is to fully understand the specific situation being studied. Next, you must carefully identify all the relevant quantities and variables that matter to that problem. Finally, you should make a rough estimate or quick calculation to check whether the potential answer actually makes logical sense. This sequence emphasizes that exact calculations are not always immediately necessary. This structured approach helps students build strong intuition, quickly detect reasoning errors, and develop deep confidence in their scientific thinking habits.

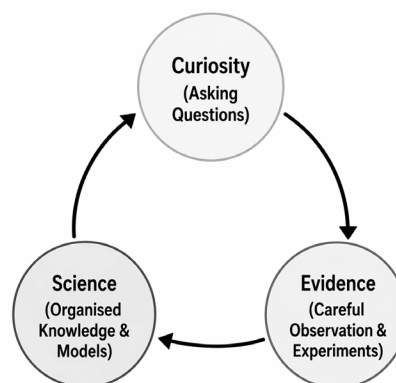
120. What would happen if we tried to study a complex natural system, like a flying bird, in its full detail without using any simplified scientific models?

Ans :

If we attempted to study a flying bird in its absolute full detail without using simplified models, the scientific task would be virtually impossible. We would be completely overwhelmed by having to simultaneously analyze every single feather's movement, the microscopic metabolic reactions in every muscle cell, fluctuating wind currents, and gravitational variations. The sheer complexity would prevent us from understanding the fundamental mechanics of flight. By not simplifying the system, we would fail to isolate the most important variables, making it impossible to answer specific aerodynamic questions.

121. Draw a simple diagram showing the continuous relationship between science, curiosity, and evidence. How do these three elements work together to build knowledge?

Ans :



Science is fundamentally a human activity deeply shaped by curiosity and the rigorous gathering of evidence. Curiosity initially drives individuals to ask insightful questions about how the natural world works. To answer these questions, scientists conduct careful experiments and observations to gather solid, measurable evidence. This evidence is then meticulously analysed to formulate models, laws, and theories, which collectively build scientific knowledge. In turn, this newly organized knowledge often sparks further curiosity, creating a continuous cycle of discovery that helps us understand the complex world.

122. What specific details would you include and what details would you ignore to build a simple mathematical model of a bicycle commute? Why?

Ans :

To build a simple mathematical model of a bicycle commute from home to school, I would primarily include crucial details like the total physical distance of the route, the average cycling speed, and major traffic stops. I would deliberately ignore minor aesthetic details such as the exact colour of the bicycle, the brand of the tires, or a slight breeze in the air. Ignoring these irrelevant factors is highly useful because they do not significantly impact the total travel time, keeping the calculation manageable and efficiently answering the core question.

LONG ANSWER QUESTIONS

123. (a) Differentiate between a scientific law, a theory, and a principle. Provide one example of each from your scientific understanding?
- (b) Why are scientific theories never considered 'final' or 'perfect'?

Ans :

- (a) A scientific law describes a regular pattern observed in nature, often expressed using mathematical relationships, such as Newton's laws of motion which explain the jerk felt when a bus stops. A theory goes further by providing a reasoned explanation for why those observed patterns occur, based on extensive evidence gathered over time, like the atomic theory explaining how molecules are formed. Principles are broad ideas that help make sense of specific situations, such as the principle of conservation of energy applied when climbing stairs.
- (b) Scientific theories are never considered final or perfect because they are always open to improvement. As new evidence emerges through better technology or precise measurements, theories are repeatedly tested. If predictions fail under new conditions, the theory must be revised or discarded. This openness to correction by nature ensures our understanding continuously evolves.

124. (a) What is a scientific model and why do scientists deliberately ignore certain details when building one?
- (b) Illustrate this using the example of a cricket shot, mentioning which details are kept and which are ignored?

Ans :

- (a) A scientific model is a simplified representation of a complex real-world system. It focuses only on the most important variables for a given question while deliberately ignoring other details. This simplification is necessary because the natural world is extraordinarily complex, and studying it in full detail is often impossible. By making assumptions, scientists keep things simple enough to find answers to specific questions.
- (b)

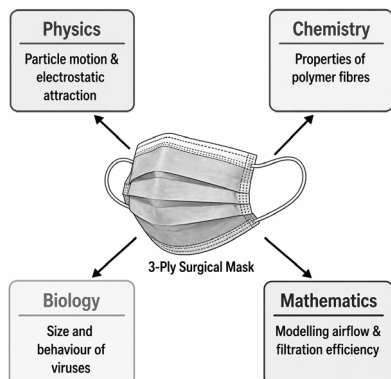


For example, when modelling a cricket shot to predict if it will cross the boundary, essential details like the mass of the ball, the speed, and the direction of the hit are included. However, irrelevant details such as the brand of the bat, the colour of the ball, or the amount of grass on the field are ignored. Minor factors like air resistance or seam stitching might also be neglected initially but added later for greater accuracy.

125. (a) Draw a conceptual diagram illustrating how a surgical mask works. Explain how understanding the functioning of a mask requires knowledge from multiple branches of science like physics, chemistry, and biology?
- (b) Why do we divide science into branches if the natural world does not have such boundaries?

Ans :

(a)



Solving real-world problems often requires connecting ideas from multiple disciplines. The functioning of a surgical mask perfectly illustrates this interdisciplinary nature. Physics is involved in understanding particle motion and the electrostatic attraction used to trap microscopic droplets. Chemistry explains the properties of the specialized polymer fibres making up the mask. Biology is essential for understanding the size, structure, and transmission behaviour of the viruses being blocked. Mathematics helps model airflow and calculate efficiency.

- (b) Despite the natural world functioning as a single interconnected system, we divide science into branches like physics, chemistry, and biology merely to organise knowledge. These artificial divisions make it easier to study complex phenomena systematically in school. However, to fully understand real-world problems, we must integrate these branches, as no single discipline holds all the answers independently.
126. (a) Explain the importance of using Standard International (SI) units globally with the help of the “airplane fuel miscalculation” incident?
- (b) How does mathematics act as a language of science rather than just a calculation tool?

Ans :

- (a) Using Standard International (SI) units globally is crucial for clear communication and preventing disastrous errors in scientific and real-world applications. A famous airplane fuel miscalculation highlights this importance. The ground crew mistakenly used pounds per litre instead of the required kilograms per litre. Consequently, the aircraft received significantly less fuel than needed and ran out mid-flight. Standard agreed units, like the kilogram, ensure scientific results are universally comparable, avoiding confusion and ensuring safety in daily life.
- (b) Furthermore, mathematics acts as a precise language in science rather than a mere calculation tool. It allows relationships between quantities to be expressed unambiguously. Mathematical equations are compact statements about how things are related, helping scientists reason carefully about motion, chemical reactions, or energy changes. It aids in understanding a situation conceptually before finding numerical answers, acting as a helpful guide for exploration.

127. (a) Why is making a rough estimate an important skill in science even when exact calculations are possible?
- (b) Using the example of estimating the daily calorie requirement from rice for a family, explain how approximations help in building scientific intuition?

Ans :

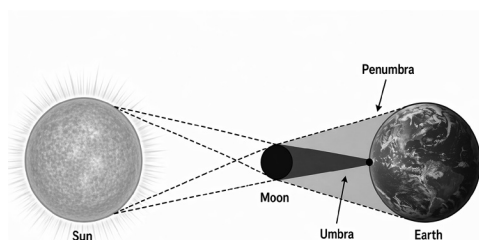
- (a) Making a rough estimate is a vital scientific skill because it helps us quickly determine whether a calculated answer is reasonable or impossible without needing exact numbers. Estimation builds scientific intuition, detects fundamental errors early in reasoning, and connects scientific concepts to everyday questions about food and resources. Science values this careful approximate reasoning highly.
- (b) For example, estimating the daily rice requirement for a family of four can be done using rough calorie approximations. An average adult needs about 2000–2500 kilocalories daily. By knowing the approximate calories in 100 g of uncooked rice, we can estimate the family’s monthly need. The goal is not an exact figure, but to verify that 100

grams is clearly too little for a month, while a few tonnes is absurdly high. This confirms our reasoning is on the right track and prevents gross miscalculations.

128. (a) Draw a labelled diagram showing the basic geometry of a total solar eclipse. Use scientific reasoning to debunk the viral claim that “eating food during an eclipse is harmful”?
- (b) What does this debunking tell us about the importance of scientific thinking?

Ans :

(a)



A viral myth claims that eating food during a solar eclipse is harmful. This can be debunked by asking simple scientific questions. A solar eclipse is simply a play of shadows when the moon blocks the sun's light. The temperature does not change significantly enough to spoil food, and food does not suddenly go bad if left in a regular shadow. There is absolutely no physical, chemical, or biological mechanism supporting the idea that food becomes toxic.

- (b) Debunking such claims demonstrates the importance of scientific thinking. It teaches us not to accept statements based purely on belief or widespread circulation. Instead, scientific thinking encourages us to evaluate information critically, seek measurable evidence, and rely on logical reasoning.

129. (a) Who was Meghnad Saha and what did he study?
- (b) How did he simplify the complex environment of a star to build his scientific model?
- (c) What was he able to explain through this simplification?

Ans :

- (a) Meghnad Saha was an eminent Indian physicist who made significant contributions

to astrophysics, specifically by studying the light emitted from stars.

- (b) The environment inside a star is incredibly complex, involving countless atoms and intricate reactions occurring simultaneously. To make sense of this overwhelming complexity, Saha built a simplified scientific model. He deliberately ignored many complex processes and did not attempt to model every single atom or every minute reaction occurring inside the stellar core. Instead, he treated the matter within the star simply as a hot gas. He focused only on crucial macro-variables: temperature, pressure, and how atoms formed ions under these extreme conditions.
- (c) Through this brilliant simplification, Saha was successfully able to explain how the specific colour of a star is deeply connected to its temperature, proving that omitting complex details can lead to profound discoveries.

130. (a) “No scientific theory is ever final and none is beyond question.” Justify this statement based on how science progresses?
- (b) How does the failure of a scientific theory or model actually contribute to the progress of science?

Ans :

- (a) The statement “no scientific theory is ever final” highlights that science is a continuously evolving process. Theories are explanations based on available evidence at a given time. As technology improves and measurements become more precise, scientists explore new conditions where established theories might fail. Science is always open to being corrected by nature, meaning theories are constantly revised or even discarded when they no longer match new, accurate observations.
- (b) The failure of a scientific theory is not a weakness; it is actually science's greatest strength. When predictions fail, scientists are forced to re-examine their assumptions, measurements, and models. This critical re-evaluation drives further exploration and prevents science from stagnating based on dogma. By rejecting ideas that contradict evidence, failures lead to the development of more accurate models, ultimately providing a deeper, more reliable understanding of the natural world.

131. (a) Why do everyday words like 'work' or 'force' have very specific and unambiguous meanings in science?
- (b) Explain the historical origin of the symbol 'c' used to denote the speed of light, and why standard symbols are important?

Ans :

- (a) In everyday language, words like 'work', 'force', or 'reaction' are used loosely with multiple meanings. However, in science, these terms have highly specific and unambiguous definitions. This precision is necessary because scientific ideas must be communicated clearly globally. A shared standard language allows scientists across different countries to describe observations accurately, compare experimental results without confusion, and build collaborative ideas using a defined unit for each physical quantity.
- (b) Similarly, scientific symbols often derive from history and international agreements rather than simple English abbreviations. For example, the speed of light is denoted by the symbol 'c'. This does not stand for any English word but originates from the Latin word 'celeritas', which translates to speed. Today, 'c' is universally recognized as a physical constant, demonstrating how standard symbols prevent regional confusion and unify scientific literature worldwide.

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CASE BASED QUESTIONS

132. Ravi is designing a school project to demonstrate how a rocket launches into space. To explain the concept to his classmates, he decides to build a simplified version using a long cardboard tube and an inflated balloon attached to the top. When he releases the balloon, the air rushes out, and the tube slides along a string across the classroom. While building this, Ravi completely ignores the outer paint color of a real space rocket, the exact shape of the astronaut cabin, and the logos printed on the side. He only focuses on the air pressure inside the balloon and the weight of the cardboard tube to make sure his project moves forward successfully.

QUESTIONS:

- (a) What is Ravi creating to help his classmates understand the complex reality of a rocket launch?
- (b) Why did Ravi choose to ignore the paint color and logos of the rocket in his project?
- (c) How does Ravi's approach compare to how physicist Meghnad Saha studied the light from stars?
- (d) Why is deliberately ignoring certain details in science not considered a mistake?

Ans :

- (a) Ravi is creating a scientific model, which is a simplified way of looking at a real system to understand how it works.
- (b) Ravi ignored the paint color and logos because they have no effect on the motion and basic physics of the launch. He focused only on the details that matter for his specific question, like pressure and weight.
- (c) Just as Ravi ignored paint and logos, Meghnad Saha ignored every atom and complex reaction inside a star, treating it simply as a hot gas to focus on temperature, pressure, and ion formation.
- (d) Ignoring certain details is not a mistake because it is done on purpose to keep things simple enough to study, allowing scientists to find answers to specific questions without getting lost in the immense complexity of the natural world.

133. A local bakery in a busy town decides to order a special type of yeast from a new international supplier. The bakery's master recipe clearly states that they need 50 units of yeast for their massive weekend bread production. The bakery manager sends the order assuming the supplier will send 50 kilograms. However, the international supplier operates in a different country and ships 50 pounds of yeast instead. When the weekend arrives, the bakers use the entire shipment for their dough. The bread fails to rise properly, ruining the entire batch and causing huge financial losses for the bakery.

QUESTIONS:

- (a) What specific scientific and mathematical concept did the bakery manager and supplier fail to align on?
- (b) Why is it essential for scientists and tradespeople worldwide to use agreed international standards for measurements?

- (c) Recall a similar real-world incident mentioned in your science studies where a unit mix-up caused a major failure.

Ans :

- (a) They failed to align on standard units of measurement, confusing kilograms with pounds.
- (b) Using agreed international standards, like the SI units, ensures that scientific results can be accurately compared, avoids conversion errors, and guarantees fairness and consistency in daily life and trade everywhere in the world.
- (c) A well-known incident involved a passenger aircraft running out of fuel mid-flight because the ground crew miscalculated the fuel using pounds per litre instead of kilograms per litre, nearly causing a disaster.

- 134.** During a science club debate, Priya strongly argues that a scientific theory is nothing more than a wild guess that scientists have not yet been able to prove. She claims, "If a theory ever gets proven with 100 percent certainty, it is upgraded to a scientific law." The club supervisor, Mr. Sharma, politely steps in to correct this common misunderstanding. He explains how objects falling to the ground and the invisible structure of atoms represent two entirely different ways scientists organize their understanding of nature. He emphasizes that theories and laws serve different purposes and one does not simply become the other.

QUESTIONS:

- (a) Was Priya correct in stating that a scientific theory is just an unproven guess?
- (b) Based on scientific definitions, differentiate between a scientific law and a scientific theory.
- (c) Provide one example of a scientific theory and one example of a scientific law.
- (d) What happens to a scientific theory when new, contradictory evidence is discovered?

Ans :

- (a) No, Priya was incorrect. A scientific theory is not an untested guess; it is a reasoned explanation based on evidence gathered over time and careful testing.
- (b) A scientific law describes a regular pattern observed in nature, often using mathematical relationships. A scientific theory goes a step

further and provides an explanation of why those observed patterns occur.

- (c) An example of a scientific theory is the atomic theory (explaining how molecules are formed). An example of a scientific law is Newton's laws of motion (explaining the jerk felt when a bus stops).
- (d) Scientific theories are always open to improvement. When new evidence becomes available, theories are often revised or changed. No scientific theory is ever final.

- 135.** Harish, a young farmer, observes that his tomato plants seem to grow much taller when he adds a specific homemade compost made of vegetable peels. Excited, he tells his neighbor, "I guarantee that this compost will make all types of vegetables grow double their normal size in exactly one week!" His neighbor, a retired science teacher, smiles and suggests that Harish is making a huge leap. The neighbor advises Harish to formulate specific, measurable questions to test his claim properly across different plants, rather than relying on a general feeling based on a single tomato plant observation.

QUESTIONS:

- (a) What scientific strength is Harish attempting to use when he makes his claim about the compost's future effects?
- (b) Why is Harish's current prediction considered unscientific or incomplete by his neighbor?
- (c) Suggest two scientifically testable questions Harish could ask to verify his prediction properly.
- (d) If Harish measures his future crops and they do not double in size, what should his next step be as a scientific thinker?
- (e) Why do scientifically based predictions, like weather forecasts, sometimes go wrong despite using good measurements?

Ans :

- (a) Harish is attempting to make a prediction, which is the ability to anticipate what will happen under new conditions before performing an experiment.
- (b) Harish's prediction is incomplete because it is a broad guess not based on rigorous measurable evidence across different conditions. Good predictions require careful reasoning and testable parameters, not just an isolated observation.

- (c) Harish could ask: “What is the exact height difference in centimeters between spinach plants grown with and without the compost after 7 days?” or “Does the compost change the soil humidity percentage compared to normal soil?”
- (d) If predictions do not match observations, Harish should re-examine his assumptions, adjust his compost model, or change his initial ideas based on the new evidence.
- (e) Weather forecasts depend on many changing factors (temperature, pressure, humidity). Tiny differences in these initial conditions can grow over time, leading to completely different outcomes, making long-term predictions less certain.

136. A group of friends is planning a week-long camping trip in a remote forest for four people. They need to pack all their drinking water in the car. One friend suggests carrying a single 10-litre water jug for the entire trip, claiming it will be plenty. Another friend quickly pauses and calculates in her head: an average person needs about 2 to 3 litres of water a day. She multiplies this by four people, and then by seven days. She immediately points out that 10 litres is drastically insufficient and that they need closer to 60 or 70 litres, saving the group from a dangerous situation.

QUESTIONS:

- (a) What specific scientific skill did the second friend use to evaluate the water requirement?
- (b) Why was an exact, precise calculation down to the milliliter not necessary to reject the first friend's suggestion?
- (c) How does this skill of making rough calculations help students and scientists in their daily reasoning?

Ans :

- (a) The second friend used the skill of estimation or making a rough estimate.
- (b) An exact calculation was unnecessary because an approximate estimate was enough to tell whether the first friend's result (10 litres) was reasonable or impossible. The gap between 10 litres and the estimated 70 litres was so large that the error was obvious.
- (c) Estimation helps build intuition, detect errors quickly, develop confidence in thinking, and connect science to everyday questions about resources, showing that approximate reasoning is a highly valuable scientific tool.

137. A large coastal city is designing a new sea wall to protect against rising ocean levels and severe storms. The engineering team consists of several different experts working together. One expert studies the physical force of the crashing waves. Another analyses the chemical makeup of the seawater to ensure the wall's concrete doesn't corrode. A third expert studies the local marine life, ensuring the wall doesn't destroy the breeding grounds of native fish. Finally, a fourth expert uses complex mathematical formulas to model the financial costs and structural longevity over the next fifty years.

QUESTIONS:

- (a) Which branch of science is primarily used by the expert analysing the corrosion of the concrete by seawater?
- (b) Identify the branch of science involved in studying the effect of the sea wall on native fish breeding grounds.
- (c) How does this scenario demonstrate the relationship between different branches of science in the real world?
- (d) Give another real-life where multiple branches of science are needed to understand or solve a problem.

Ans :

- (a) The expert analyzing the chemical makeup and corrosion is primarily using chemistry.
- (b) The expert studying the native fish and marine life is using biology.
- (c) This scenario demonstrates that the natural world does not have rigid boundaries. Solving real-world problems requires integrating physics, chemistry, biology, and mathematics, as these disciplines enrich each other and are not independent.
- (d) Understanding how a COVID-19 safety mask works requires physics (electrostatic attraction of particles), chemistry (properties of polymer fibers), biology (size of viruses), and mathematics (modelling airflow). Another example is understanding climate change.

138. An international team of engineers from India, Japan, and Germany is collaborating online to design an electric car engine. They do not share a common spoken language and rely heavily on translation software for meetings. However, when they share their engineering blueprints and

technical documents, the translation software is hardly needed. The documents are filled with specific letters like v, I, F, and m, alongside numbers. The diverse team understands the blueprints perfectly, allowing them to work seamlessly together to build a highly efficient engine.

QUESTIONS:

- (a) What do the symbols v, I, F, and m represent in the shared language of science?
- (b) Why do scientists use these specific symbols and a shared language instead of relying solely on everyday conversational words?
- (c) Why is the speed of light specifically denoted by the letter 'c', and what does it reveal about scientific symbols?

Ans :

- (a) In science, 'v' represents velocity, 'I' represents electric current, 'F' represents force, and 'm' represents mass.
- (b) Everyday words can be ambiguous or mean different things in different languages. Symbols provide a precise, specific, and shared language that allows scientists across the world to communicate clearly, describe observations accurately, and build ideas together without confusion.
- (c) The speed of light is denoted by 'c' based on the Latin word 'celeritas', meaning speed. This reveals that scientific symbols often come from history and are based on international agreements rather than just being simple English abbreviations.

- 139.** During a solar eclipse, a rumor quickly spreads on social media claiming that looking at the sun during the eclipse will permanently alter human DNA, turning people into mutants. The message urges everyone to hide in windowless basements. A ninth-grade student reads this and decides to evaluate the claim critically. She knows an eclipse is simply the moon casting a shadow on the Earth. She asks herself if standing in a shadow has ever chemically altered someone's DNA before. Realizing there is no physical, chemical, or biological mechanism that supports light blockage mutating DNA, she confidently ignores the viral message.

QUESTIONS:

- (a) How did the student approach the viral social media claim scientifically?

- (b) According to scientific thinking, on what basis should claims or ideas be accepted or rejected?
- (c) How does the student's reasoning mirror the textbook's explanation of the myth about eating food during a solar eclipse?
- (d) Why is this openness to questioning and evidence considered the greatest strength of science?

Ans :

- (a) The student approached the claim by asking simple, logical scientific questions, breaking down the physical reality of the event (it's just a shadow), and looking for a scientific mechanism to support the claim.
- (b) Claims and ideas should not be rejected or accepted based on popular opinion or belief, but only on measurable evidence and careful reasoning.
- (c) Just like the student concluded that a shadow cannot alter DNA, the textbook explains that a shadow cannot make food harmful, as there is no physical, chemical, or biological mechanism that causes food to go bad simply because it is in a shadow.
- (d) Science's greatest strength is that no theory is ever final or beyond question. This openness to being corrected by nature and evidence allows our understanding of the world to constantly improve and protects us from false myths.

- 140.** A track and field coach is teaching his athletes how to pace themselves for a marathon. Instead of just telling them to "run steadily," he writes an equation on the white board showing the relationship between their target distance, the time they want to achieve, and their required average velocity. One student groans, complaining that this feels like a difficult math class instead of sports training. The coach calmly explains that he isn't trying to make them do hard arithmetic, but rather using the formula as a short, clear way to show exactly how their running speed will decide their finishing time.

QUESTIONS:

- (a) How is mathematics being utilized by the coach in this training scenario?
- (b) According to your science textbook, is mathematics in science meant to be just a calculation tool? Explain.

- (c) How does identifying the mathematical relationships between quantities help a student in science?
- (d) Give another example from the textbook where mathematical expressions are used to describe patterns.

Ans :

- (a) The coach is using mathematics as a compact statement or language to clearly communicate the relationship between speed, distance, and time to his athletes.
- (b) No, mathematics in science is not just a calculation tool. It is a powerful language for thinking more clearly about the world and stating how certain things are related.
- (c) By focusing on understanding the situation and identifying relevant quantities first, mathematics becomes a helpful guide to reason carefully, predict outcomes, and answer questions about physical events, rather than just an obstacle of numbers.
- (d) Mathematical expressions are used to describe the rates of chemical reactions, patterns of population growth, or changes in energy within a system.

- 141.** A group of students is taken on a nature walk in a dense forest reserve to learn about local ecosystems. Before entering the woods, the guide hands the group two symbolic items: a magnifying glass and a compass. During the walk, he asks the students to use the magnifying glass to look closely at the veins of the leaves and the trail of ants, noticing tiny details they would usually walk right past. Later, when the path becomes confusing, he tells them to use the compass to ensure they are heading north toward the river, ensuring their walk has a clear destination.

QUESTIONS:

- (a) In the context of secondary science exploration, what does looking closely at the leaves with the magnifying glass symbolize?
- (b) What does the directional tool or compass represent in scientific exploration?
- (c) According to the textbook, what happens when careful observation and purposeful direction are combined in science?
- (d) Why is science described as a human activity rather than just a textbook collection of facts?

Ans :

- (a) The magnifying glass symbolizes careful observation, noticing patterns, asking questions, and paying attention to vital details in nature that might otherwise be missed.
- (b) The compass reminds us that exploration needs direction. It represents choosing appropriate models, asking the right testable questions, and knowing the limits of our ideas.
- (c) Together, they tell us that exploration in science is not wandering aimlessly. It is a deliberate attempt to make sense of our world with care, evidence, and purpose.
- (d) Science is a human activity because it is shaped by curiosity, creativity, collaboration, and careful questioning. It grows dynamically as people ask questions, test ideas, share results across cultures, and learn from mistakes over time.

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CHAPTER 2

Cell: The Building Block of Life

SUMMARY

1. INTRODUCTION

It is widely accepted that life originated in water. All living organisms — from the tiniest bacterium to the largest tree — are made up of cells. Unicellular organisms such as bacteria and yeast consist of only one cell, while multicellular organisms such as plants, fish, birds, and humans are made up of millions of cells working together. A group of similar cells performing similar functions forms a tissue. Different tissues organise to form an organ, and several organs work together to form organ systems — for example, the nasal pores, nasal cavity, trachea, and lungs form the respiratory system. Even when organised into tissues and organ systems, the cell remains the fundamental unit of structure and function in all living organisms.

2. HOW TO STUDY CELLS?

2.1 Limit of Resolution of Human Eye

The human eye (viewed at 25 cm) can distinguish two points only if they are at least 0.1 mm (100 μm) apart. Points closer than this appear as one — this distance is called the limit of resolution. Most cells are below this threshold, so microscopes are essential.

2.2 Types of Microscopes

1. Light Microscope: Light Microscope — uses visible light with objective lenses ($10\times$, $40\times$); used in school labs. Resolution $\approx 0.2 \mu\text{m}$.
2. Electron Microscope: Electron Microscope — uses beam of electrons; reveals structures at nanometre scale ($1 \text{ nm} = 0.000001 \text{ mm}$).

Robert Hooke (1665) : First person to observe a cell using a self-designed microscope ($\sim 200\text{--}300\times$

magnification). Examining a thin slice of cork, he named small box-like compartments

3. STRUCTURE OF A CELL

Cells interact with surroundings at their boundary — the cell membrane. Even single-celled organisms exchange materials through it.

3.1 Cell membrane — The universal feature of a cell

The cell membrane (plasma membrane) is a thin, selectively permeable boundary made of lipids and proteins that protects the cell and controls substance movement. Water crosses it by osmosis (from dilute to concentrated solution), while diffusion is movement from higher to lower concentration. In plants, water enters root cells by osmosis.

In an isotonic solution, no net movement occurs; in a hypotonic solution, cells swell; and in a hypertonic solution, cells shrink.

According to the fluid-mosaic model, the membrane has a lipid bilayer with embedded proteins that move freely, giving it a fluid and mosaic-like structure.

3.2 Cell wall — The outer covering of cells

Plants, fungi, and bacteria have a cell wall outside the cell membrane that provides support and protection. In plants, it is made of cellulose and helps maintain shape, keep cells firm, and support upright growth. Cellulose also acts as roughage in our diet.

The cell wall is permeable, allowing water and minerals to pass through. In a concentrated solution, plant cells lose water but do not shrink due to the rigid wall; instead, the membrane pulls away from it, a process called plasmolysis. Animal cells lack a cell wall, so they shrink completely and can easily change shape.

4. THE CELL INTERIOR — A COORDINATED WORKING SYSTEM

Most cells have three basic parts: a selectively permeable plasma membrane, a semi-fluid jelly-like substance called the cytoplasm, and a prominent nucleus. In addition to the nucleus, the cytoplasm contains several sub-cellular components called organelles, along with other substances. Most organelles are visible only with an electron microscope.

Prokaryotic vs. Eukaryotic Cells

A bacterial cell lacks a well-defined nucleus and membrane-bound organelles. Such cells are called prokaryotic cells (pro = primitive, karyon = nucleus). In prokaryotic cells, most cellular activities take place directly in the cytoplasm. In contrast, plant and animal cells have a well-defined nucleus and several membrane-bound organelles. Such cells are called eukaryotic cells (eu = true). These cells are larger and more complex, typically 10–100 μm in diameter, compared with 1–10 μm for prokaryotes.

4.1 Why do eukaryotic cells need these organelles?

Eukaryotic cells carry out various life processes independently at the same time in different cell organelles. Cell organelles help in building new materials, removing waste, and providing energy. A cell is like a tiny living factory where parts work together to perform functions.

Nucleus — House of coded instructions

The nucleus has a double membrane with pores for exchange of materials. It contains the nucleolus, where ribosome components are formed. Chromosomes inside the nucleus carry genetic information in the form of DNA, and genes are its functional units.

In non-dividing cells, DNA exists as chromatin, which condenses into chromosomes during division. Mature red blood cells lack a nucleus, allowing more space for haemoglobin. In prokaryotes, DNA is present as a circular molecule in a region called the nucleoid.

Ribosomes — The protein factories

Ribosomes are tiny structures present freely in the cytoplasm or attached to the endoplasmic reticulum. Ribosomes are the sites of protein synthesis.

Endoplasmic Reticulum (ER) — Manufacturing factory

The endoplasmic reticulum (ER) is a network in the cytoplasm connected to the nuclear membrane. It helps in the synthesis and transport of proteins, fats, and some hormones.

Rough ER has ribosomes and is involved in protein synthesis and secretion, while smooth ER lacks ribosomes and helps in making and storing fats and hormones.

Golgi apparatus — The packaging and shipping centres

The Golgi apparatus consists of stacks of flattened sac-like structures. It is functionally linked to the ER, the cell membrane, and other cell organelles. The Golgi apparatus acts like the post office of the cell. It modifies, sorts, and packages proteins and lipids into vesicles for transport, secretion, or lysosome formation. The Golgi apparatus was first observed in 1898 by Italian scientist Camillo Golgi in the nerve cells of a barn owl.

Lysosomes — The clean-up system

Lysosomes are single membrane-bound sacs filled with enzymes. These enzymes break down unwanted proteins, carbohydrates, fats, and damaged parts of the cell. Lysosomes keep the cell clean and healthy. The broken down products are released into the cytoplasm to be reused. Human sperm cells contain lysosomal enzymes to break down the outer layer of the egg during fertilisation.

5. MITOCHONDRIA — THE POWERHOUSE OF THE CELL

Mitochondria supply the energy needed for most cellular activities. Each mitochondrion is surrounded by two membranes. The outer membrane is smooth and porous. The inner membrane is folded into finger-like projections called cristae. Cristae increase the surface area for chemical reactions and facilitate energy production. Glucose and other molecules are broken down to release energy during cellular respiration in mitochondria. Energy is stored in the form of Adenosine Triphosphate molecules. Adenosine Triphosphate acts as the energy currency for cellular activities.

6. PLASTIDS — CENTRE FOR FOOD SYNTHESIS IN THE PLANT CELLS AND BEYOND

Plastids are organelles in plants that help in food synthesis and storage. Chloroplasts contain chlorophyll and carry out photosynthesis. They have a double membrane, with a fluid stroma containing disc-like structures and stored sugars.

Plastids and mitochondria have their own DNA and can make some proteins. Chromoplasts contain coloured pigments, while leucoplasts are colourless and store food like starch, oils, or proteins.

7. VACUOLES — THE ORGANELLES FOR STORAGE AND SUPPORT

A mature plant cell usually has one large central vacuole surrounded by a single selectively permeable membrane. The vacuole is filled with a watery fluid called cell sap. The vacuole stores water, minerals, sugars, and waste material. The vacuole maintains pressure inside the cell to keep the plant cell firm. A plant cell becomes less firm and wilts when the vacuole loses water. Animal cells sometimes have small vacuoles for the temporary storage of materials. In 2010, scientist J. Craig Venter created a synthetic cell by inserting chemically synthesised DNA into a bacterium cell that had its original DNA removed.

8. HOW DO NORMAL CELLS GROW AND DIVIDE?

Cells in the body grow and divide to replace old, dead, or damaged cells. Cells grow up to a certain size and then divide to form new cells. The cells of a growing onion root tip divide continuously and show various stages of cell division. Hundreds of billions of cells in the human body are replaced every day. Prokaryotic and eukaryotic cells both divide. Eukaryotic cells divide in a controlled and orderly manner by a process called the cell cycle.

8.1 Cell division

Cell division is the formation of new cells from existing ones, helping in growth, repair, and reproduction. It occurs in two main types: mitosis and meiosis.

1. Mitosis produces two identical daughter cells with the same DNA and chromosome number as the parent cell. It is important for growth, tissue repair, and asexual reproduction.

2. Meiosis occurs in reproductive organs to form gametes. It produces four cells with half the chromosome number. During fertilisation, the original number is restored, and variation is created among offspring.

9. CELL THEORY — THE UNIFYING PRINCIPLE OF BIOLOGY

An important observation about living organisms is that all organisms are made up of cells. In 1838, German botanist Matthias Schleiden reported that all plants are made up of cells. In 1839, German zoologist Theodor Schwann found that all animals are also made up of cells. Later, in 1855, German scientist Rudolf Virchow further expanded the Cell Theory by stating that new cells are formed only from pre-existing cells. Together, their work led to the formulation of the Cell Theory.

According to the classical Cell Theory:

1. All living organisms are made up of one or more cells.
2. The cell is the basic unit of structure and function in living beings.
3. All cells arise from pre-existing cells.

9.1 Do cells grow and reproduce forever?

Cells grow, divide in a controlled way, carry out functions, and eventually die when no longer needed. Dead cells are replaced by new cells that carry out the same function. Every cell has a definite life span. Animal cell division usually stops when cells come in contact with neighbouring cells through a process called contact inhibition. Cancer cells lose contact inhibition and keep dividing uncontrollably to form tumours. Plant cells have rigid cell walls and do not show contact inhibition. Programmed Cell Death is a genetically regulated process of selective cell destruction. Programmed Cell Death is essential for normal development, cellular quality control, and immune function. Cancerous tumours can invade nearby tissues and spread to other parts of the body to form new tumours.

PAUSE AND PONDER

1. What argument would you give for the necessity of a cell wall in plants usually fixed in one place versus in animals usually moving from one place to the other?

Ans :

Plants are rooted in one location and cannot physically move to seek shelter from harsh environmental stresses like strong winds, heavy rain, or temperature extremes. The rigid cell wall provides them with the necessary structural strength, protection, and ability to remain upright against these conditions. In contrast, animals can actively move to seek shelter or avoid danger, so they do not require a rigid outer layer, and lacking a cell wall allows their bodies the vital flexibility needed for locomotion.

2. What consequences would you predict for a plant cell if its cell wall were to become as flexible as a cell membrane?

Ans :

If the plant cell wall became as flexible as a cell membrane, the plant would lose its structural rigidity and ability to stand upright, causing it to quickly wilt or collapse. Additionally, the cell would become highly vulnerable to bursting in dilute environments because it relies on the rigid cell wall to push back against the internal pressure of water entering via osmosis.

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3. Why is it important to cut the two potato pieces in roughly equal size and measure their initial weight before placing them in different liquids?

Ans :

Cutting the potato pieces into roughly equal sizes ensures that both pieces have a similar starting surface area, making the rate and extent of osmosis comparable between the two experimental setups. Measuring the initial weight establishes a critical baseline to accurately calculate the difference in mass after the experiment concludes. Without this initial measurement, it would be impossible to scientifically determine or quantify exactly how much water was gained or lost by the potato cells due to osmosis in the different solutions.

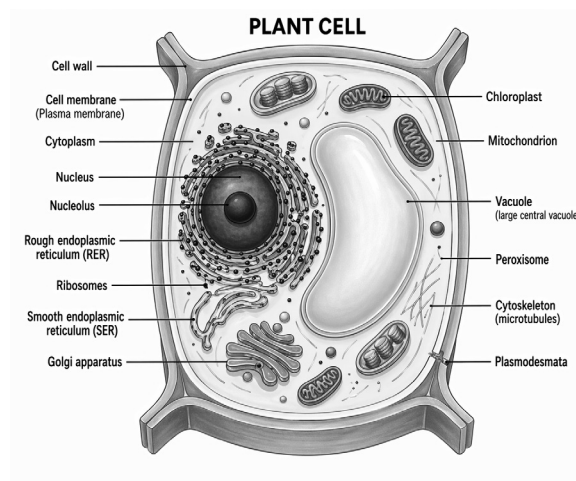
4. Do white flowers contain any pigment? Give reasons.

Ans :

White flowers generally do not contain any specific white pigment to give them their colour. Instead, their cells contain colourless plastids called leucoplasts, which lack pigment and are primarily used for storing starch, oils, or proteins. The white appearance of the petals is actually caused by the reflection and scattering of all visible light by the microscopic air spaces and cellular structures within the flower tissue.

5. Draw a well-labelled schematic diagram of a plant or an animal cell using these clues — (i) Nucleus appears as a dark and round body inside the cell. (ii) ER spreads like a network of extended nuclear envelope. (iii) Mitochondria and chloroplasts are rod shaped. You may refer to figure.

Ans :



6. Instead of many small ones, why does a cell not have a single giant mitochondrion? How does this relate to the concept of surface area?

Ans :

A cell has many small mitochondria rather than a single giant one to maximize the total surface area available for energy-producing chemical reactions. Mitochondria generate energy along their inner membranes, and having multiple smaller organelles significantly increases the overall surface area-to-volume ratio within the cell. This larger total surface area ensures a much faster, more efficient production and distribution of ATP to meet the continuous energy demands of the cell.

1. If the skin cells start dividing by meiosis instead of mitosis, what do you think will happen to a cut on the skin?

Ans :

If skin cells divided by meiosis, the cut would not heal properly because meiosis produces daughter cells that are genetically different and contain only half the normal number of chromosomes. For damaged tissue to be repaired effectively, the new replacement cells must be exact genetic copies of the original skin cells with a full set of chromosomes, a process that can only be achieved through mitosis.

NCERT EXERCISE

1. Differentiate between the following pairs of terms based on the clues given in parentheses:
- Cell membrane and cell wall (permeability)
 - RER and SER (structure)
 - Chloroplasts and chromoplasts (pigments)

Ans :

- Cell membrane and cell wall (permeability) : The cell membrane is selectively permeable, meaning it allows only certain substances to pass through while blocking others. In contrast, the plant cell wall is freely permeable, allowing water and dissolved minerals to pass through it without strict selectivity.
- RER and SER (structure) : Rough Endoplasmic Reticulum (RER) appears rough under an electron microscope because it has tiny structures called ribosomes attached to its surface. Smooth Endoplasmic Reticulum (SER) appears smooth because it lacks these attached ribosomes on its surface.
- Chloroplasts and chromoplasts (pigments): Chloroplasts contain the green pigment chlorophyll, which is essential for trapping sunlight during photosynthesis. Chromoplasts contain other colored pigments, such as yellow, orange, or red, which impart bright colors to flower petals and fruits to attract pollinators and animals.

2. Two similar animal cells are placed in two different solutions:

- Cell X is placed in pure water.
- Cell Y is placed in a concentrated salt solution.

Cells are observed after some time. Cell X swells, and Cell Y shrinks. Which statement provides the correct explanation for the above observations?

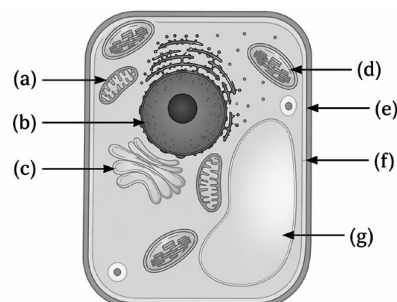
- Salt molecules moved into Cell Y, causing it to shrink.
- Water moved into Cell X and more water moved out of Cell Y than the salt solution entered in it.
- Water moved into Cell X and moved out of Cell Y through the cell membrane.
- Solute movement caused osmosis in both cells.

Ans :

Option (iii) Water moved into Cell X and moved out of Cell Y through the cell membrane.

Justification: Osmosis is the movement of water across a selectively permeable membrane. Pure water is a dilute medium causing water to enter and swell Cell X, while the concentrated salt solution draws water out of Cell Y, causing it to shrink.

3. Look at the diagram of a cell in figure. Identify the parts labelled from (a) to (g) and correctly match them with their functions given below:



- Controlling all the activities of a cell.
- Site of cellular respiration.
- Storage organelle that also provides rigidity to the cell.
- Separates the cell contents from surroundings.
- Provides structural rigidity to the cell.
- Packs and stores materials received from ER.
- Helps in manufacturing food.

Ans :

Based on Figure showing a plant cell, the parts and their matched functions are:

- Nucleus: (i) Controlling all the activities of a cell.
- Golgi apparatus: (vi) Packs and stores materials received from ER.

- (c) Chloroplast: (vii) Helps in manufacturing food.
- (d) Cell wall: (v) Provides structural rigidity to the cell.
- (e) Cell membrane: (iv) Separates the cell contents from surroundings.
- (f) Mitochondria: (ii) Site of cellular respiration.
- (g) Vacuole: (iii) Storage organelle that also provides rigidity to the cell.

4. Which of the following option(s) of the pairs of cell organelles are correctly placed under the given categories?

Option	Present in the plant cells	Absent in the animal cells
(i)	Leucoplast	Cell wall
(ii)	Mitochondria	Ribosome
(iii)	Cell wall	Golgi apparatus
(iv)	Lysosome	Endoplasmic reticulum

Ans :

Option (i) is correctly placed.

Leucoplasts are plastids found in plant cells for storage, and the cell wall is an outer rigid structure present in plant cells but completely absent in animal cells. The other options list organelles like ribosomes, Golgi apparatus, and endoplasmic reticulum as absent in animal cells, which is factually incorrect as animal cells possess all of these.

5. Two students, Renu and Rohit, were having a discussion on the plastids. Renu emphasised that all parts of the plants, even roots, contain plastids. However, Rohit did not agree with the statement and told her that plastids are absent in plant roots since the roots are underground and do not need to perform photosynthesis. Who is correct? Justify your answer.

Ans :

Renu is correct. While Rohit is right that underground roots generally do not perform photosynthesis, plastids serve more functions than just capturing sunlight. Plant roots contain a type of colourless plastid called leucoplasts. These leucoplasts do not have pigments but play a crucial role in storing food materials such as starch, oils, or proteins for the plant, proving that plastids are indeed present in roots.

6. Mitochondria and chloroplasts are two important organelles in a plant cell. Discuss how these two organelles are structurally and functionally similar to each other, and different from each other.

Ans :

Structurally, both mitochondria and chloroplasts are similar because they are double-membrane-bound organelles and both contain their own DNA and ribosomes, allowing them to synthesise some of their own proteins. Functionally, they are similar in that both are deeply involved in cellular energy processes. However, they differ significantly in their specific roles. Mitochondria are the powerhouses of the cell that carry out cellular respiration to break down food and release energy in the form of ATP. In contrast, chloroplasts contain chlorophyll and are the sites of photosynthesis, where they capture light energy to synthesise food (sugars) for the plant cell.

7. Which of the following pairs of cell organelles contains DNA?

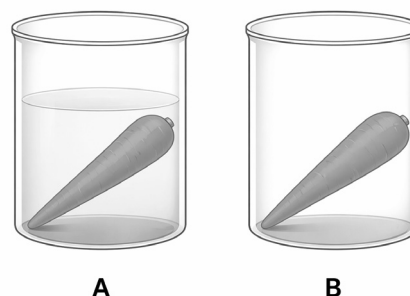
- (i) Chloroplasts, Ribosomes
- (ii) Mitochondria, Nucleus
- (iii) Golgi bodies, Ribosomes
- (iv) Nucleus, Lysosomes

Ans :

Option (ii) Mitochondria, Nucleus.

Justification: of coded instructions containing the primary genetic material (DNA) of the cell. Additionally, mitochondria are unique organelles that possess their own circular DNA, sharing this trait with plastids like chloroplasts.

8. A researcher carried out an experiment in which she took two carrots of similar size. She placed one carrot in plain water and the other carrot in concentrated salt solution. After 24 hours she recorded her observations.



- (i) What hypothesis does she want to test through this experiment?
- (ii) What would you suggest for the improvement of this experiment?
- (iii) Why does the carrot in plain water stay stiff and crunchy, but the carrot in concentrated salt solution become rubbery and limp?

Ans :

- (i) The researcher likely wants to test the hypothesis that plant cells will undergo osmosis depending on their surrounding medium, specifically that they will absorb water in a dilute solution and lose water in a concentrated solute solution.
- (ii) To improve the experiment, the researcher should measure and record the initial weight and precise dimensions of both carrots before placing them in the solutions. By comparing these initial measurements with the final weight and dimensions after 24 hours, she would obtain reliable quantitative data to support her visual observations.
- (iii) The carrot in plain water stays stiff because plain water is a dilute solution, causing water to enter the carrot cells via osmosis and build up firm turgor pressure against the cell walls. The carrot in the concentrated salt solution becomes rubbery because the surrounding solution has a lower water concentration, causing water to move out of the carrot cells into the solution, leading to a loss of internal pressure and firmness.

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9. Indicate the presence or absence of following structures in bacterial and animal cells:

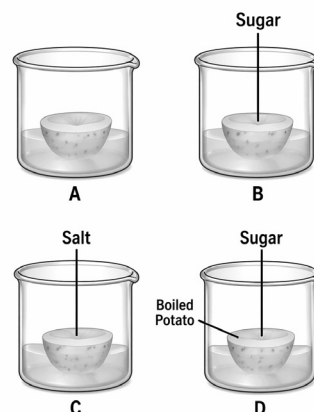
Structures in a cell	Bacterial cell	Animal cell
Chromosome		
Nucleus		
Mitochondria		
Golgi complex		
Chromoplasts		

Ans :

Structures in a cell	Bacterial cell	Animal cell
Chromosome	Present	Present
Nucleus	Absent	Present
Mitochondria	Absent	Present
Golgi complex	Absent	Absent
Chromoplasts	Absent	Absent

10. Carry out the following experiment:

Take four peeled potato halves and scoop each one out to make potato cups. One of these potato cups should be made from a boiled potato. Place each of the potato cups in a beaker containing water. Now, set up the experiment as follows:



- (a) Keep Cup A empty.
- (b) Add one teaspoon sugar in Cup B.
- (c) Add one teaspoon salt in Cup C.
- (d) Add one teaspoon sugar in the boiled potato in Cup D.

Observe the four potato cups at least two hours and answer the following questions:

- (i) Explain why water gathers in the hollowed portion of Cup B and Cup C.
- (ii) Why is Cup A necessary for this experiment?
- (iii) Explain why water does not gather in the hollowed portions of Cups A and D.

Ans :

- (i) Water gathers in Cup B and Cup C due to the process of osmosis. The addition of sugar and salt creates a highly concentrated solution inside the potato cups. Because the living potato cells act as a selectively permeable membrane, water moves from the area of higher water concentration in the beaker

into the hollowed cups to balance the solute concentrations.

- (ii) Cup A acts as a control for the experiment. By remaining empty and showing that water does not gather inside on its own, it proves that the movement of water into Cups B and C is specifically caused by the presence of the solutes (sugar and salt).
- (iii) Water does not gather in Cup A because there is no solute inside to create a concentration gradient that would draw water in. Water does not gather in Cup D because boiling the potato kills its cells and destroys the selectively permeable nature of the cell membranes, which is an absolute requirement for osmosis to take place.

11. Identify the pair that incorrectly matches the cell organelle with its function.

- (i) Ribosome — Protein synthesis
- (ii) SER — Lipid and cellulose synthesis
- (iii) Lysosome — Digestion of foreign agents

Ans :

Option (ii) SER — Lipid and cellulose synthesis is the incorrectly matched pair.

While the Smooth Endoplasmic Reticulum (SER) is indeed involved in the synthesis and storage of fats and lipids, it does not synthesise cellulose. Cellulose is a carbohydrate primarily found in the plant cell wall, and its synthesis is not a function of the SER.

12. What outcome do you expect, if all the mitochondria are removed from a eukaryotic cell?

Ans :

If all mitochondria are removed from a eukaryotic cell, the cell will lose its ability to perform cellular respiration and generate energy. Because mitochondria act as the powerhouses that supply ATP for most cellular activities, the sudden lack of energy would quickly cause vital cell functions to stop, ultimately leading to the death of the cell.

13. Which phenomenon inhibits the formation of tumors in the human body? Can plants also develop tumors? Explain.

Ans :

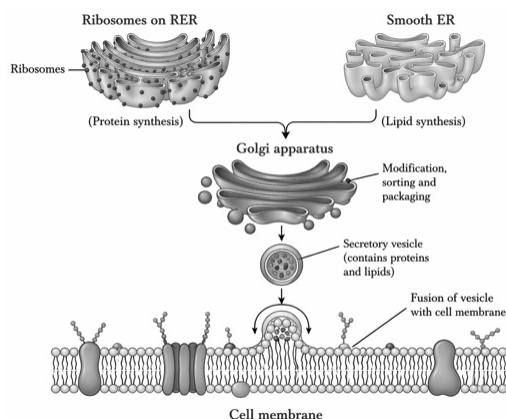
The phenomenon that inhibits the formation of tumors in the human body is called contact inhibition, a process where normal cells stop

dividing uncontrollably when they come in contact with neighbouring cells. Plants can also develop tumors, but they do so differently. Because plant cells have rigid cell walls, they do not exhibit contact inhibition like animal cells do, meaning their cells follow a different pattern of growth and can still form tumor-like growths when control systems fail.

14. The cell membrane of a cell is made up of proteins and lipids. Which cell organelles help in the synthesis of cell membrane? Write the path of these compounds from their site of synthesis to the cell membrane and show this through a labelled diagram.

Ans :

The Endoplasmic Reticulum (ER) and the Golgi apparatus help in the synthesis of the cell membrane. The Rough Endoplasmic Reticulum (RER) synthesises the membrane proteins, and the Smooth Endoplasmic Reticulum (SER) synthesises the membrane lipids. Once produced, these proteins and lipids travel in transport vesicles from the ER to the Golgi apparatus. The Golgi apparatus modifies, sorts, and packages these materials into new secretory vesicles, which then move to and fuse with the existing cell membrane, expanding it.



15. What would happen if gametes are formed by mitotic divisions?

Ans :

If gametes were formed by mitosis instead of meiosis, they would contain a full set of chromosomes identical to the parent cell, rather than having half the number. When these gametes combined during fertilisation, the resulting offspring would have double the normal number

of chromosomes. This doubling would continue uncontrollably with every successive generation, destroying genetic stability and causing severe developmental failures.

16. A farmer, Deepa, was very happy with the harvest of amla (Indian Gooseberry) and lemons on her farm. However, she could sell only one-fourth of the produce in the local market. Recognising that a significant amount of produce may be lost post-harvest, she employed a traditional yet scientifically sound method to extend the shelf life of amla and lemons. She turned perishable produce into profitable products, such as pickles and sharbat. She used the excess produce to prepare pickles, murabbas, and sharbat by adding appropriate amounts of salt, sugar, or jaggery to small pieces of fruit and their juices. These were then stored in small glass bottles for sale, helping her prevent the wastage of post-harvest produce. This shift from farming to agro-processing would strengthen food security and boost the local economy, creating a sustainable model that cuts waste while increasing her income. Based on the above passage answer the following questions:

- Which scientific concept has the farmer applied in the preservation of the farm produce?
- How does the addition of high concentrations of salt and sugar create an environment that prevents the growth of spoilage-causing bacteria and fungi?
- Suggest a healthy recipe of this kind for food preservation.
- What are the scientific values addressed in this case?

Ans :

- The farmer has primarily applied the scientific concept of osmosis in preserving her farm produce.
- Adding high concentrations of salt or sugar creates a highly concentrated (hypertonic) environment around the food. Due to osmosis, water is drawn out of any spoilage-causing bacteria or fungi that land on the food. This severe water loss shrinks and kills the microbial cells, thereby preventing them from growing and spoiling the food.
- A healthy preservation recipe would be making a mixed vegetable pickle. You can cut vegetables like carrots, cauliflower, and green chilies, dry them slightly in the sun to remove

surface moisture, and mix them with spices, highly concentrated salt, and a small amount of mustard oil to create an environment where spoilage microbes cannot survive.

- The scientific values addressed include critical thinking and problem-solving by using the biological principle of osmosis to address real-world challenges. It also demonstrates an understanding of sustainability by minimizing food waste, and shows economic awareness by applying scientific knowledge to transform perishable farm yields into long-lasting, valuable goods.

OBJECTIVE QUESTIONS

- In the hot springs of the Puga Valley in Ladakh, temperatures remain nearly at the boiling point of water despite the cold climate. Which of the following types of organisms predominantly inhabit these extreme environmental conditions?
 - Multicellular green algae
 - Complex eukaryotic fungi
 - Heat-loving bacteria called thermophiles
 - Cold-adapted specialized protozoans

Ans : (C)

Hot springs in the Puga Valley of Ladakh maintain very high temperatures even in cold climates. The organisms living in these extreme environments are mostly heat-loving bacteria called thermophiles. These unicellular organisms survive conditions similar to early Earth, helping scientists understand the origin of cellular life forms in harsh habitats.

- What is the standard limit of resolution of the human eye when viewing two tiny objects from a distance of 25 centimetres?
 - 1.0 millimetres
 - 0.1 millimetres
 - 0.01 millimetres
 - 10 micrometres

Ans : (B)

The limit of resolution of the human eye is defined as the minimum distance at which two closely placed objects appear distinct. When viewed from twenty-five centimetres, two points separated by about zero point one millimetres can be seen clearly. If they are placed closer, they appear as one point.

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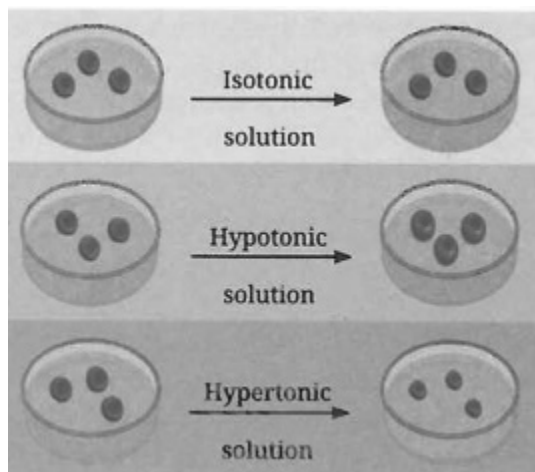
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3. The given diagram illustrates animal cells placed in a specific type of solution. Based on the visual changes in the cells, what is the nature of the surrounding medium?



- (A) It is a hypotonic solution, causing water to enter the cells and leading them to swell.
 (B) It is a hypertonic solution, causing water to leave the cells and leading them to shrink.
 (C) It is an isotonic solution, where the net movement of water across the membrane is zero.
 (D) It is a saturated solution, where solute particles enter the cells and cause them to shrink.

Ans : (B)

The diagram shows cells shrinking, indicating water is moving out. This occurs when the external medium has a higher solute concentration than the cell's interior, known as a hypertonic solution. Hypotonic solutions cause swelling, isotonic solutions maintain cell shape, and solutes do not primarily dictate volume changes here.

4. Who was the first person to observe cell structures using a self-designed microscope while examining a thin slice of cork in the year 1665?
 (A) Theodor Schwann
 (B) Matthias Schleiden
 (C) Rudolf Virchow
 (D) Robert Hooke

Ans : (D)

In the year sixteen sixty-five, English scientist Robert Hooke used a self-designed microscope to examine a thin slice of cork. He observed small, box-like compartments that resembled tiny rooms. He coined the term cells for these structures,

marking a significant milestone in biology and the beginning of widespread microscopic exploration.

5. A student observes an onion peel under a light microscope. The visible circular field of view has a measured diameter of 6000 micrometres. If exactly 30 cells are aligned perfectly along this diameter, what is the estimated actual size of a single onion cell?
 (A) 20 micrometres
 (B) 200 micrometres
 (C) 180 micrometres
 (D) 500 micrometres

Ans : (B)

To calculate the actual size of a single cell under a microscope, divide the total diameter of the visible field by the number of cells spanning that diameter. Here, the visible field diameter is six thousand micrometres. Dividing this by thirty cells gives an estimated actual cell size of two hundred micrometres.

6. **Assertion (A):** The cell membrane is also referred to as a selectively permeable membrane.
Reason (R): It allows all metabolic substances to pass freely in and out of the cell without restriction.
 (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

The cell membrane is a thin boundary that protects cellular contents and separates them from the external environment. It is called selectively permeable because it controls movement by allowing certain substances to pass through while blocking others. Therefore, the assertion is true, but the provided reason is factually completely false.

7. The structural organization of the cell membrane is best explained by the fluid-mosaic model. According to this universally accepted model, which component specifically acts as the critical gatekeeper helping selected molecular substances pass through?
 (A) The continuous water-attracting lipid heads
 (B) The hydrophobic water-repelling lipid tails
 (C) The specialized embedded membrane proteins
 (D) The highly rigid crystalline cellulose fibres

Ans : (C)

The fluid-mosaic model accurately describes the cellular membrane structure. It comprises a flexible lipid bilayer with specific water-attracting heads facing outwards and water-repelling tails pointing inwards. Specialized proteins are strategically embedded within this fluid lipid layer, functioning effectively as dynamic gatekeepers that actively regulate the passage of various molecular substances.

8. A student observes four different onion peel slides under a light microscope. Using the data in the table, determine which slide contains the largest estimated cell size.

Slide	Diameter of visible field (μm)	Number of cells along diameter
Slide A	2000	10
Slide B	1500	5
Slide C	4000	40
Slide D	3000	12

- (A) Slide A
(B) Slide B
(C) Slide C
(D) Slide D

Ans : (B)

The estimated size of a single cell is calculated by dividing the diameter of the visible field by the total number of cells along that diameter. Slide B yields the largest size at 300 micrometres (1500 divided by 5). The other slides yield smaller sizes of 200, 100, and 250 micrometres respectively.

9. A freshly cut piece of raw potato is completely submerged in a beaker containing a twenty percent salt solution. After two hours, a noticeable visible change occurs in the size of the potato piece. What happens and why?
- (A) It drastically swells because the external medium is strongly hypotonic.
(B) It significantly shrinks because the external medium is severely hypertonic.
(C) It remains completely unchanged because the external medium is perfectly isotonic.
(D) It rapidly bursts due to extreme uncontrolled inward osmotic water pressure.

Ans : (B)

When a freshly cut potato piece is placed in a twenty percent salt solution, the external medium

becomes distinctly hypertonic. Because the solute concentration outside is significantly higher than inside the potato cells, water rapidly moves out through the selectively permeable membrane via osmosis, ultimately causing the entire potato piece to shrink.

10. Consider the following specific physiological statements regarding cellular responses to different external solution concentrations:
1. A cell placed in an isotonic solution shows no net movement of water across its boundary.
 2. A cell placed in a hypotonic solution rapidly loses water and shrinks considerably.
 3. A cell placed in a hypertonic solution actively absorbs water and swells significantly.
- Which of the above statements is/are scientifically correct?
- (A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2, and 3

Ans : (A)

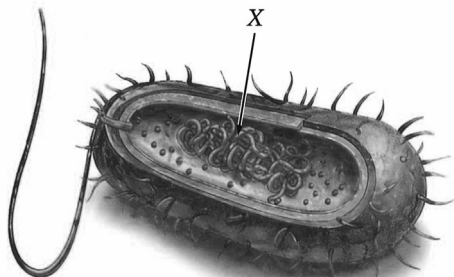
In an isotonic solution, the concentration of the extracellular medium perfectly matches the intracellular medium, resulting in no net movement of water. A hypotonic solution has less solute outside, causing cells to swell. A hypertonic solution has more solute outside, causing water to exit and the cell to noticeably shrink.

11. In biological systems, the net movement of molecular particles from a region of higher concentration to a region of lower concentration occurs spontaneously. What is the specific term used when this exact process involves the critical diffusion of water molecules strictly across a selectively permeable membrane?
- (A) Active transport
(B) Facilitated diffusion
(C) Osmosis
(D) Endocytosis

Ans : (C)

Diffusion is the net movement of particles from a region of higher concentration to a lower concentration until equilibrium is reached. It can occur in any medium and does not require a membrane. Osmosis is specifically the targeted diffusion of water molecules across a selectively permeable membrane along a concentration gradient.

12. Observe the diagram of the given cell. Which of the following correctly identifies the structural region marked 'X' and describes its defining characteristic?



- (A) Nucleolus; a dense spherical structure responsible for synthesising ribosomal subunits.
 (B) Nucleoid; an undefined nuclear region containing genetic material without a membrane.
 (C) Nucleus; a double-membrane-bound organelle storing tightly packed chromosomes.
 (D) Cytoplasm; a jelly-like substance where most cellular chemical reactions occur.

Ans : (B)

The cell depicted is a bacterium, which is prokaryotic. The region marked 'X' represents the nucleoid, where the single circular DNA molecule is located freely without a surrounding nuclear envelope. A true nucleus, nucleolus, and membrane-bound organelles are exclusively found in eukaryotic cells, making the other options incorrect.

13. Arrange the following distinct biological entities in the correct increasing order based on their typical physical dimensional scale, starting from the absolutely smallest structural unit:
1. Typical bacterial cell
 2. Atoms
 3. Simple chemical proteins
 4. Viruses
 5. Mature human animal cell
- (A) 2, 3, 4, 1, 5
 (B) 2, 4, 3, 1, 5
 (C) 3, 2, 1, 4, 5
 (D) 4, 3, 2, 1, 5

Ans : (A)

Biological structures naturally follow a specific hierarchical scale based on physical dimensions.

Atoms combine to form small molecules, which then assemble into larger proteins. Viruses are larger than proteins but remain smaller than the simplest bacteria. A typical plant or animal cell is significantly larger than bacteria, completing this increasing progression.

14. Plants uniquely possess an additional outer rigid covering located immediately outside their fragile cell membrane. Which of the following statements accurately describes a fundamental functional characteristic of this specific plant cell wall?
- (A) It completely blocks the external entry of all environmental water and minerals.
 (B) It primarily functions to actively synthesize cellular lipid and cellulose molecules.
 (C) It remains highly permeable, allowing dissolved minerals and essential water to easily pass.
 (D) It rapidly dissolves itself when the plant cell is exposed to concentrated hypertonic solutions.

Ans : (C)

Although the plant cell wall provides crucial rigid structural support to withstand environmental stresses, it remains fundamentally permeable. This critical characteristic allows essential water and dissolved minerals to pass through freely. The selective permeability is strictly maintained by the underlying cell membrane, which tightly controls actual entry into the cell interior.

15. Match the highly specialized eukaryotic cell organelles listed in List-I with their uniquely specific biological functions provided in List-II.

List-I

- P. Golgi apparatus
 Q. Lysosomes
 R. Mitochondria
 S. Nucleus

List-II

1. Cellular clean-up system utilizing potent digestive enzymes
 2. The central house of coded genetic instructions
 3. Primary site responsible for active energy production
 4. The essential packaging and shipping centre of the cell
- (A) P-4, Q-1, R-3, S-2
 (B) P-1, Q-4, R-2, S-3
 (C) P-4, Q-2, R-1, S-3
 (D) P-3, Q-1, R-4, S-2

Ans : (A)

The Golgi apparatus actively packages and ships materials. Lysosomes serve as the cellular clean-up system containing digestive enzymes. Mitochondria generate energy in the form of adenosine triphosphate. The nucleus contains genetic codes and completely directs overall cellular functions. This logically links each specific cell organelle to its accurately described biological role.

16. Identical pieces of potato were placed in four beakers containing unknown sugar solutions. Based on the mass changes recorded in the table, which beaker contained a hypotonic solution?

Beaker	Initial mass of potato piece (g)	Final mass after 2 hours (g)
Beaker P	5.0	5.0
Beaker Q	5.0	6.2
Beaker R	5.0	3.8
Beaker S	5.0	4.5

- (A) Beaker P
(B) Beaker Q
(C) Beaker R
(D) Beaker S

Ans : (B)

In a hypotonic solution, the surrounding medium has a higher water concentration than the cell interior. Water moves into the cell through osmosis, causing the cell to swell and gain mass. Only the potato piece in Beaker Q shows an increase in mass, confirming it was placed in a hypotonic medium.

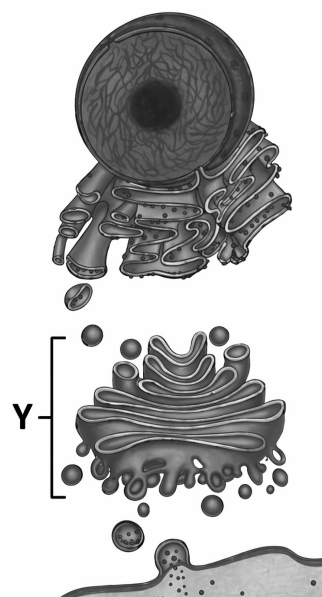
17. Unlike complex eukaryotic cells, primitive bacterial cells completely lack a true membrane-bound nucleus. Instead, their genetic material typically exists as a single continuous circular DNA molecule. What is the specific scientific term used to accurately describe this undefined genetic region within a prokaryotic cell?
- (A) Nucleolus
(B) Nucleoid
(C) Chromatin
(D) Nuclear envelope

Ans : (B)

Prokaryotic cells, such as basic bacteria, fundamentally lack a well-defined, membrane-bound nucleus to house their genetic material.

Instead, their DNA exists as a single circular molecule freely suspended within the cytoplasm. This specific, undefined central region containing the vital genetic material is scientifically referred to as the nucleoid in prokaryotic organisms.

18. The diagram displays an interconnected system of cellular organelles. What is the primary function of the organelle labelled 'Y'?



- (A) It synthesises lipid molecules and steroid hormones for the cell membrane.
(B) It serves as the primary site for cellular respiration and ATP generation.
(C) It breaks down complex organic waste materials using digestive enzymes.
(D) It modifies, sorts, and packages proteins into vesicles for targeted transport.

Ans : (D)

Organelle 'Y' represents the Golgi apparatus, identifiable by its stacks of flattened, sac-like structures. It functions as the cell's packaging centre, processing proteins received from the endoplasmic reticulum and directing them into vesicles. Lipid synthesis occurs in the smooth endoplasmic reticulum, ATP generation in mitochondria, and waste breakdown in lysosomes.

19. **Assertion (A):** Mature human red blood cells essentially lack a defined nucleus inside their mature cellular structure.

Reason (R): The deliberate absence of a nucleus specifically provides additional internal space for haemoglobin, thereby significantly maximizing vital cellular oxygen transport capacity.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

Mature human red blood cells do not have a nucleus. This absence provides more space within the cell to accommodate a larger amount of haemoglobin, which significantly increases their efficiency in transporting oxygen throughout the body. Therefore, both assertion and reason are completely true, and the reason correctly explains the assertion.

20. Based on the structural characteristics provided in the table, identify the organism(s) that represent a prokaryotic cell.

Organism	Nuclear membrane	Membrane-bound organelles	Diameter of typical cell (μm)
Organism 1	Absent	Absent	2
Organism 2	Present	Present	50
Organism 3	Present	Present	20

- (A) Organism 1 only
 (B) Organism 2 only
 (C) Organisms 2 and 3
 (D) Organisms 1 and 3

Ans : (A)

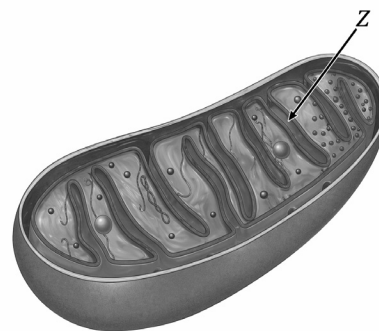
Prokaryotic cells are generally smaller in size (1 to 10 micrometres) and lack both a well-defined nuclear membrane and membrane-bound organelles. Organism 1 exhibits these primitive structural features, indicating it is a prokaryote. Organisms 2 and 3 possess true nuclei and distinct organelles, classifying them as eukaryotic cells.

21. The nucleus centrally contains genetic material crucial for the ongoing inheritance of traits. In an actively dividing eukaryotic cell, the loose genetic material structurally condenses into distinct, well-organized, highly visible rod-shaped structures. What are these specific condensed rod-shaped structures correctly called?
 (A) Chromatin threads
 (B) Nucleoli bodies
 (C) Chromosomes
 (D) Ribosomal subunits

Ans : (C)

Inside a non-dividing eukaryotic cell, essential DNA is loosely present as an entangled mass of thread-like structures known as chromatin. However, whenever the cell prepares to undergo division, this loose chromatin material tightly condenses and neatly organizes itself into distinct rod-shaped structures universally recognized by scientists as discrete cellular chromosomes.

22. The provided diagram illustrates an organelle often referred to as the powerhouse of the cell. What is the functional significance of the structural folding marked 'Z'?



- (A) It decreases the internal volume to maintain a high concentration of respiratory enzymes.
 (B) It increases the internal surface area to maximise the production of cellular energy.
 (C) It traps light energy effectively by organising photosynthetic pigments into dense layers.
 (D) It stores synthesised glucose and other essential carbohydrates for future cellular requirements.

Ans : (B)

The structure marked 'Z' points to the cristae, which are finger-like projections of the mitochondrion's inner membrane. These folds significantly increase the available surface area for chemical reactions associated with cellular respiration, thereby facilitating maximum ATP production. They do not trap light energy, store glucose, or primarily decrease internal volume.

23. Within the double-layered membrane of the eukaryotic cellular nucleus lies a dense, distinctly round body known as the nucleolus. What is the absolutely primary biological function actively performed by this specific intranuclear structural body?
 (A) Producing functional adenosine triphosphate molecules

- (B) Synthesizing essential sub-units for cellular ribosomes
- (C) Storing excess complex lipid and starch molecules
- (D) Directly breaking down severe internal cellular waste

Ans : (B)

The nucleolus is a dense, round structure prominently located within the eukaryotic nucleus. It serves as the primary site where crucial ribosomal subunits are actively synthesized. Once formed, these important subunits exit through nuclear pores into the cytoplasm, where they fully assemble to create functional ribosomes responsible for massive protein production.

- 24.** A researcher introduces fluorescently labelled amino acids into a cell to track protein synthesis and secretion. The table records the location of the highest concentration of these proteins over time. Identify Organelles X and Y.

Time elapsed (minutes)	Location of highest protein concentration
5	Organelle X (described as having a rough surface)
20	Organelle Y (described as stacked sacs)
45	Plasma membrane

- (A) X is Smooth Endoplasmic Reticulum, Y is Lysosome
- (B) X is Rough Endoplasmic Reticulum, Y is Golgi apparatus
- (C) X is Golgi apparatus, Y is Rough Endoplasmic Reticulum
- (D) X is Mitochondria, Y is Vacuole

Ans : (B)

Proteins are synthesized by ribosomes attached to the rough endoplasmic reticulum, making it the first location of high concentration. These proteins are then transported to the Golgi apparatus, a structure of stacked sacs, where they are modified, sorted, and packaged into vesicles before being secreted through the plasma membrane.

- 25.** Consider the following specific descriptive statements regarding the rigid plant cell wall:
1. It is primarily composed of a complex structural carbohydrate known as cellulose.

2. It completely replaces the underlying flexible plasma membrane in mature plant cells.
3. It specifically prevents delicate plant cells from continuously shrinking in hypertonic mediums.
4. It crucially helps leaves and flowers maintain strict shape and firmness during environmental stress.

Which combination of the above statements is biologically correct?

- (A) 1 and 4 only
- (B) 2 and 3 only
- (C) 1, 3, and 4 only
- (D) 1, 2, 3, and 4

Ans : (A)

The plant cell wall is a rigid outer covering composed primarily of cellulose, providing essential structural support. While rigid, it remains highly permeable to water and dissolved minerals. Animal cells completely lack this structure, which is why they easily change shape and can burst when placed in highly hypotonic environments.

- 26.** Inside complex eukaryotic cells, the clear cytoplasm serves as a dynamic medium containing numerous membrane-bound organelles. Additionally, the cytoplasm actively stores specific non-living substances like excess starch granules or crystalline silica. What is the formal scientific term utilized to accurately describe these non-living stored substances?
- (A) Cytoskeletal fibres
 - (B) Active internal transport vesicles
 - (C) Cellular cytoplasmic inclusions
 - (D) Primary central storage vacuoles

Ans : (C)

The cytoplasm is a semi-fluid substance filling the cell interior, housing all specialized organelles. In many eukaryotic cells, it also serves as a critical storage site for essential materials. These non-living stored substances, clearly known as cell inclusions, include excess starch in plant cells and specific calcium oxalate or silica crystals.

- 27.** Certain microscopic biological infectious agents are considered completely acellular because they lack fundamental standard cellular organization entirely and cannot be clearly visualized under normal light microscopes. Among the following options, which agent entirely lacks any internal

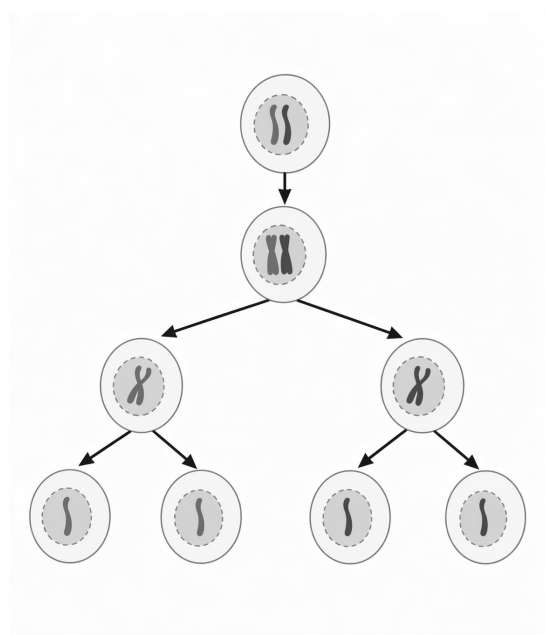
genetic material like DNA or RNA?

- (A) Complex human viruses
- (B) Simple plant viroids
- (C) Infectious disease-causing prions
- (D) Typical primitive bacteria

Ans : (C)

Viruses and prions are unique infectious agents considered completely acellular because they lack basic cellular structures. Viruses typically consist of specific genetic material heavily protected by a protein coat. Prions are entirely distinct because they are merely misfolded proteins that entirely lack any internal genetic material like DNA or RNA molecules.

- 28.** The given flowchart illustrates a specific type of cellular division. Which biological process fundamentally relies on this exact pattern of division?



- (A) The continuous replacement of dead or damaged skin cells.
- (B) The vegetative growth of a plant stem towards a light source.
- (C) The production of gametes within the reproductive organs.
- (D) The healing of a tissue wound after a physical injury.

Ans : (C)

The diagram depicts meiosis, identifiable by the two consecutive division stages resulting in four distinct daughter cells, each containing half the

original chromosome number. This process is exclusively responsible for producing gametes like sperm and eggs. Tissue repair, general growth, and cell replacement all rely strictly on mitosis, which produces two identical cells.

- 29.** Read the following detailed functional statements concerning the extensive Endoplasmic Reticulum (ER) membrane network within eukaryotic cells:
1. The rough endoplasmic reticulum features attached ribosomes and primarily participates in active protein synthesis.
 2. The smooth endoplasmic reticulum distinctly lacks attached ribosomes and fundamentally focuses on internal lipid synthesis.
 3. The internal endoplasmic reticulum membrane network is physically isolated and entirely separated from the outer nuclear envelope.

Which of the above statements is/are scientifically correct?

- (A) 1 only
- (B) 1 and 2 only
- (C) 2 and 3 only
- (D) 1, 2, and 3

Ans : (B)

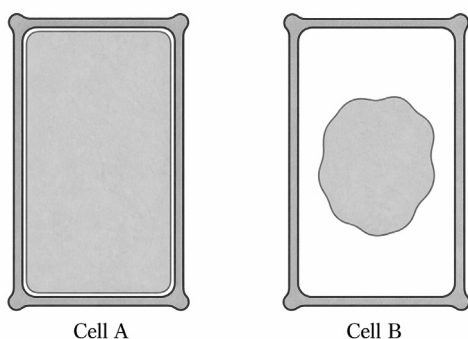
The rough endoplasmic reticulum features ribosomes on its surface, actively participating in essential protein synthesis. Conversely, the smooth endoplasmic reticulum lacks ribosomes and is primarily responsible for synthesizing lipids and storing fats. The endoplasmic reticulum membrane directly connects with the outer layer of the cell nucleus, forming a continuous network.

- 30.** While specialized glandular cells like pancreatic cells possess abundant rough endoplasmic reticulum to rapidly synthesize massive amounts of digestive proteins, other cells heavily utilize the smooth endoplasmic reticulum. What is the fundamental primary biological role specifically performed by the smooth endoplasmic reticulum?
- (A) Rapid continuous synthesis of complex ribosomal sub-units
 - (B) Extensive active packaging of waste into functional lysosomes
 - (C) Constant targeted synthesis and internal storage of crucial cellular fats
 - (D) Direct extraction of vital energy from circulating glucose molecules

Ans : (C)

The smooth endoplasmic reticulum distinctly lacks attached surface ribosomes, which gives it a completely smooth appearance under microscopic observation. Rather than synthesizing vital proteins, it is primarily responsible for the continuous manufacturing and efficient internal storage of complex cellular lipids, essential fats, and various critical circulating steroid hormones within the body.

31. Based on the depicted state of the plant cells, identify the surrounding medium for Cell B and the specific cellular process that has occurred.



- (A) Hypotonic medium, Endosmosis
 (B) Hypertonic medium, Exosmosis
 (C) Isotonic medium, Diffusion
 (D) Hypertonic medium, Endosmosis

Ans : (B)

Cell B exhibits plasmolysis, where the internal contents shrink and pull away from the rigid cell wall. This occurs when a plant cell is placed in a hypertonic medium, causing water to exit the cell through exosmosis. Hypotonic solutions cause swelling (endosmosis), and isotonic solutions result in no net movement, making other options incorrect.

32. The complex Golgi apparatus consists of highly organized stacks of flattened, sac-like structures actively involved in modifying, sorting, and packaging cellular proteins. Which brilliant historical scientist is officially credited with definitively confirming its exact structural existence within the nervous tissue of a barn owl?
- (A) Matthias Schleiden
 (B) J. Craig Venter
 (C) Camillo Golgi
 (D) Rudolf Virchow

Ans : (C)

The Golgi apparatus acts as the primary cellular post office, actively modifying, sorting, and securely packaging synthesized proteins. It was officially named in honour of Camillo Golgi, the brilliant Italian scientist who first successfully observed its complex thread-like network within the specialized nerve cells of a barn owl using special staining.

33. Based on the historical timeline of major microscopic biological discoveries, select the precise chronological sequential order in which the following highly significant cellular discoveries were definitively established by prominent scientists:

1. Initial formulation of the foundational biological cell theory.
2. Initial observation of simple cork cells using a self-designed microscope.
3. First exact description of the specialized packaging Golgi apparatus organelle.
4. Definitive proposal that all new biological cells continuously arise from pre-existing ones.

- (A) 2, 1, 4, 3
 (B) 1, 2, 3, 4
 (C) 2, 4, 1, 3
 (D) 4, 1, 2, 3

Ans : (A)

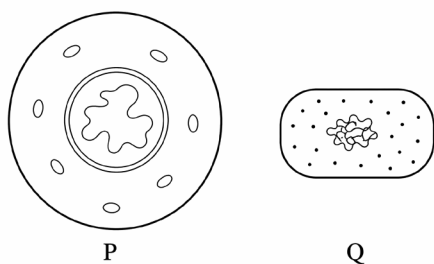
Robert Hooke first discovered cells in sixteen sixty-five. Matthias Schleiden and Theodor Schwann formulated the foundational cell theory between eighteen thirty-eight and eighteen thirty-nine. Later, in eighteen fifty-five, Rudolf Virchow expanded the theory by observing that new cells originate from pre-existing cells. Finally, Camillo Golgi discovered the Golgi apparatus in eighteen ninety-eight.

34. Lysosomes function as highly efficient clean-up systems that rapidly break down damaged internal cellular components using their potent internal enzymes. From which heavily specialized organelle are these critical membrane-bound lysosomal waste-disposal structures originally packaged and structurally formed?
- (A) The central genetic nucleus
 (B) The smooth endoplasmic reticulum network
 (C) The cellular energy-producing mitochondria
 (D) The flattened sac structures of the Golgi apparatus

Ans : (D)

Lysosomes are powerful membrane-bound sacs filled with potent digestive enzymes capable of breaking down cellular waste. These critical waste-disposal organelles do not spontaneously generate within the cell cytoplasm; instead, they are directly formed and effectively packaged into functional transport vesicles primarily by the sophisticated membranes of the active Golgi apparatus structure.

35. Which statement correctly identifies the genetic material arrangement in the depicted cellular structures?



- (A) Cell P has a nucleoid; Cell Q has a true nucleus.
 (B) Both Cell P and Cell Q possess membrane-bound nuclei.
 (C) Cell P's genetic material is enclosed in a nuclear membrane; Cell Q has a nucleoid.
 (D) Cell P is a prokaryotic cell; Cell Q is a eukaryotic animal cell.

Ans : (C)

Cell P represents a eukaryotic cell because it possesses a well-defined nucleus with a double-layered membrane enclosing its genetic material. Cell Q represents a prokaryotic cell, containing a nucleoid—an undefined region where naked genetic material floats freely in the cytoplasm without any enclosing membrane. Thus, the other structural assertions are incorrect.

36. Extremely specialized human reproductive cells exhibit numerous uniquely adapted structural features. For example, mature mobile human sperm cells inherently contain concentrated specialized lysosomal enzymes. What exact crucial biological purpose do these specific potent internal enzymes directly serve during the human sexual reproductive process?
- (A) They rapidly generate massive amounts of extra necessary cellular motility energy.

- (B) They actively break down the tough outer protective layer of the female egg.
 (C) They effectively duplicate the entire internal male genetic chromosomal DNA payload.
 (D) They continuously repair external structural damage sustained during active rapid swimming.

Ans : (B)

Human sperm cells uniquely contain concentrated lysosomal enzymes within their specialized heads. When a mobile sperm cell finally encounters a mature egg, these powerful enzymes are rapidly released to effectively break down the tough outer protective layer of the egg, thereby actively facilitating a successful fertilization process during human sexual reproduction.

37. **Assertion (A):** Mitochondria are universally referred to as the powerhouse of the complex eukaryotic cell.

Reason (R): They completely lack a protective outer membrane, directly allowing free glucose to enter rapidly for instantaneous explosive energy generation.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

Mitochondria are known as powerhouses of the cell because they produce energy necessary for cellular activities. However, the outer membrane is smooth and porous, while the inner membrane is folded into finger-like projections called cristae to increase surface area. Thus, the assertion is completely true, but the provided reason is entirely false.

38. The internal folded mitochondrial cristae significantly increase the available membrane surface area for critical complex chemical reactions. During cellular respiration, broken down glucose releases vital chemical energy. In what exact specific molecular form is this vital cellular energy fundamentally captured and internally stored?

- (A) Complex polymerized starch granules
 (B) Raw elemental gaseous oxygen
 (C) Highly energetic Adenosine Triphosphate molecules

- (D) Readily available unrefined raw glucose molecules

Ans : (C)

Inside mitochondria, glucose molecules are systematically broken down through cellular respiration to release essential vital energy. This released energy is efficiently captured and securely stored in chemical bonds to form Adenosine Triphosphate. This specific molecule acts as the universal energy currency, directly powering almost all essential metabolic activities within the cell.

39. The table provides data on cell division processes observed in different biological samples. Which samples are undergoing mitosis for the purpose of growth or tissue repair?

Cell sample	Initial chromosome number in parent cell	Final chromosome number per daughter cell	Number of daughter cells formed
Sample 1	46	46	2
Sample 2	46	23	4
Sample 3	16	16	2
Sample 4	24	12	4

- (A) Samples 1 and 2
(B) Samples 2 and 4
(C) Samples 1 and 3
(D) Samples 3 and 4

Ans : (C)

Mitosis is a type of cell division responsible for growth and repair. It produces two identical daughter cells, each retaining the exact same number of chromosomes as the original parent cell. Samples 1 and 3 maintain their chromosome numbers and produce two cells, which correctly indicates the process of mitosis.

40. Mitochondria and chloroplasts uniquely possess remarkable biological features that strongly suggest they share an ancient evolutionary history intimately related to certain primitive single-celled bacteria. Which specific distinct structural feature completely separates them from practically all other typical membrane-bound cellular organelles?

- (A) They both crucially possess a single extremely rigid external carbohydrate cell wall.

- (B) They both universally lack any kind of selectively permeable internal phospholipid boundary.
(C) They both contain their own specific internal circular DNA and functional active ribosomes.
(D) They both constantly participate in the direct active destruction of unwanted foreign bacterial agents.

Ans : (C)

Mitochondria and plastids share unique biological features that remarkably resemble certain free-living bacteria. Unlike other standard membrane-bound organelles, both possess their own specific circular DNA and functional ribosomes. This incredible evolutionary characteristic allows them to independently synthesize some of their own vital proteins without relying entirely on the central cellular nucleus.

41. Plant cells exclusively contain diverse types of highly specialized membrane-bound plastids perfectly adapted for highly specific essential biological tasks. Which specific exact category of plastid intrinsically completely lacks any internal coloured pigments and functions strictly as a dedicated long-term internal storage centre for cellular starch?
(A) Brightly coloured Chromoplasts
(B) Colourless internal Leucoplasts
(C) Green photosynthesizing Chloroplasts
(D) Enzyme-filled destructive Lysosomes

Ans : (B)

Plastids are specialized organelles exclusively found within plant cells. Chloroplasts naturally contain green chlorophyll for photosynthesis. Chromoplasts brightly store diverse pigments providing yellow or orange colours to flowers and fruits. Leucoplasts, which literally translates to white plastids, lack visible pigments entirely and primarily function to efficiently store necessary starch, oils, or proteins.

42. Match the specific distinct types of plant cell plastids listed strictly in List-I with their corresponding primary dedicated biological functional descriptions accurately provided in List-II.

List-I

- P. Leucoplasts
Q. Chloroplasts
R. Chromoplasts

List-II

- Specifically contain vital green pigment structurally required for capturing solar light energy.
 - Contain brightly coloured internal pigments specifically intended to naturally attract insect pollinators.
 - Serve exclusively as specialized colourless internal cellular compartments for storing necessary reserve nutrients.
- (A) P-3, Q-1, R-2
(B) P-1, Q-2, R-3
(C) P-2, Q-3, R-1
(D) P-3, Q-2, R-1

Ans : (A)

Chloroplasts contain green chlorophyll essential for capturing sunlight during photosynthesis. Chromoplasts house colourful pigments like yellow or orange that attract insect pollinators. Leucoplasts are colourless plastids primarily dedicated to storing nutritional materials such as starch, oils, or proteins. These distinct functions directly dictate the roles of different plastid types in plants.

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43. Mature active plant cells typically contain one enormously expanded specialized membrane-bound structure that often dominates the entire internal cellular volume. This massive structure crucially maintains essential cellular internal turgid pressure. What is this distinctly prominent, specialized internal central cellular structure specifically called?
- (A) The massively expanded central Nucleus
(B) The heavily folded internal Endoplasmic Reticulum
(C) The large distinct internal central Vacuole
(D) The rigid continuous external primary Cell Wall

Ans : (C)

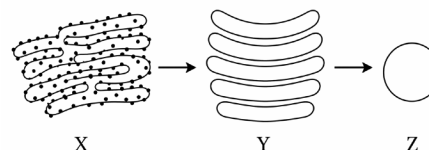
Mature plant cells typically contain one large central vacuole filled with a watery fluid known as cell sap. This prominent structure stores essential water, dissolved minerals, and waste products. By continuously exerting internal pressure against the rigid cell wall, it critically maintains cellular turgidity, keeping the entire plant firm and upright.

44. In a monumental scientific breakthrough specifically occurring in the year 2010, specialized researchers completely successfully synthesized a fully exact replica of a specific simple bacterium's DNA sequence purely from scratch using laboratory chemicals. Which prominent pioneering synthetic biologist primarily spearheaded this incredibly remarkable historical achievement?
- (A) Rudolf Virchow
(B) Camillo Golgi
(C) Gottlieb Haberlandt
(D) J. Craig Venter

Ans : (D)

In twenty-ten, scientist J. Craig Venter created a massive breakthrough in synthetic biology. His team completely synthesized an exact chemical copy of the DNA from a bacterium called *Mycoplasma mycoides*. They inserted this purely synthetic genetic material into a recipient cell, which then began to grow perfectly following the newly provided instructions.

45. Based on the indicated cellular pathway, what is the most likely biological role of Structure Y?



- (A) It synthesizes structural proteins using the attached ribosomes.
(B) It generates ATP molecules to provide energy for cellular transport.
(C) It modifies, sorts, and packages materials received from Structure X.
(D) It digests worn-out cell organelles using hydrolytic enzymes.

Ans : (C)

Structure X represents the rough endoplasmic reticulum (RER), responsible for protein synthesis. Structure Y represents the Golgi apparatus, the packaging center. It receives materials synthesized by the RER, modifies them, and packages them into vesicles (Structure Z) for transport or secretion. The other options describe functions of ribosomes, mitochondria, and lysosomes respectively.

46. The highly specialized process of meiotic cellular division occurs explicitly in distinct sequential stages to properly produce functional reproductive gametes. Identify the entirely accurate sequential chronological ordering of these major functional meiotic events:

1. Final distinct production of completely non-identical functional daughter reproductive cells.
2. Initial commencement of specialized parent cell active reproductive division.
3. Secondary distinct cellular division closely resembling standard somatic mitosis.
4. Immediate halving of the total normal parental genetic chromosomal number.

- (A) 2, 4, 3, 1
 (B) 2, 3, 4, 1
 (C) 4, 2, 1, 3
 (D) 2, 1, 4, 3

Ans : (A)

Meiosis takes place specifically in the reproductive organs to produce functional gametes. First, the parent cell undergoes an initial division into two daughter cells, where the chromosome number is immediately halved. This is followed by a second division similar to mitosis, ultimately producing four distinct daughter cells with half the chromosomes.

47. Regular ongoing mitosis represents the absolute most common type of standard cellular division occurring within the living human body. What constitutes the completely accurate definitive biological outcome resulting directly from one single complete successful cycle of standard somatic mitosis?

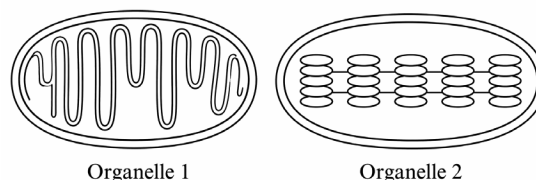
- (A) Exactly four genetically distinct diverse daughter cells possessing completely halved chromosome numbers.
 (B) Exactly two completely genetically identical daughter cells maintaining the exact original parent chromosome number.
 (C) Precisely four completely genetically identical daughter cells retaining exactly double the total normal chromosome number.
 (D) Exactly two extremely genetically varied daughter cells displaying massively increased totally random chromosomal variations.

Ans : (B)

Mitosis is the most common type of cell division responsible for basic bodily growth, regular tissue repair, and general cellular maintenance. During

this structured process, a single parent cell divides precisely once to consistently produce exactly two genetically identical daughter cells, maintaining the original specific chromosome number perfectly intact throughout generations.

48. Identify the primary physiological function associated with the specialized internal structures of these organelles.



- (A) Organelle 1: Food synthesis; Organelle 2: Energy release
 (B) Organelle 1: Energy release; Organelle 2: Food synthesis
 (C) Organelle 1: Intracellular digestion; Organelle 2: Protein packaging
 (D) Organelle 1: Lipid synthesis; Organelle 2: Starch storage

Ans : (B)

Organelle 1 is a mitochondrion, identified by its deeply folded inner membrane (cristae), which increases surface area for cellular respiration and energy release. Organelle 2 is a chloroplast, characterized by internal stacks of membrane-bound discs (thylakoids), responsible for capturing sunlight to synthesize food during photosynthesis. Therefore, Option B correctly matches their functions.

49. **Assertion (A):** Meiosis is exclusively restricted to occurring within highly specialized internal reproductive organs specifically for creating varied functional gametes.

Reason (R): It explicitly functions to produce exactly two completely genetically identical cellular clones strictly to effectively replace rapidly dying external dermal skin cells.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

Meiosis is a highly specialized type of cell division that specifically occurs in reproductive organs to

produce gametes. It does not produce identical cells; rather, it introduces genetic variations that ensure children resemble their parents but are not exactly identical. Therefore, the assertion is completely true, but the reason is completely false.

- 50.** To successfully introduce immense vital genetic diversity during natural sexual reproduction, flowering plants heavily depend upon specialized meiotic cell divisions. In which distinct explicit anatomical structures of a typical mature flowering plant does this highly specific vital meiotic division primarily occur?
- (A) Strictly inside the continuously rapidly expanding tips of deep underground nutritional roots.
- (B) Exclusively inside the broad green functional photosynthetic mesophyll leaves.
- (C) Only strictly within the central structurally highly rigid strengthening woody stems.
- (D) Exclusively inside the specialized male anthers and specifically within the protected female ovaries.

Ans : (D)

Meiosis is uniquely dedicated to creating genetic diversity for sexual reproduction. It occurs exclusively within specialized reproductive organs rather than regular somatic tissues. In typical flowering plants, meiosis explicitly takes place within the male anthers to produce pollen and within the female ovaries to ultimately form functional egg cells for fertilization.

- 51.** Modern laboratory science routinely utilizes completely artificial environments strictly designed to grow functional cells entirely isolated outside living organisms. This highly specific specialized technological process actively enables vital mass production of crucial synthetic medicines and important protective vaccines. What is this advanced scientific methodology specifically called?
- (A) Internal natural bodily somatic repair
- (B) Synthetic external artificial cell culture
- (C) Uncontrolled rapid systemic tumour formation
- (D) Complete systemic natural internal bodily apoptosis

Ans : (B)

Scientists have successfully developed specialized methods to grow plant and animal cells entirely outside the natural body. This crucial technique,

formally known as cell culture, requires maintaining highly controlled sterile conditions, providing nutrient-rich mediums, and ensuring precise temperatures. It is widely used today for producing vital biochemicals, essential medicines, and protective vaccines.

- 52.** Both major types of complex cellular divisions absolutely strictly require highly proper systemic control. When rare critical chromosomal separation errors specifically completely spontaneously occur strictly during the specialized process of meiosis, what particular severe negative medical biological consequence commonly ultimately directly results?
- (A) Immediate extreme spontaneous uncontrolled deadly widespread systemic cancerous tumour formation.
- (B) Complete immediate instantaneous miraculous regeneration of highly damaged severed spinal nerve tissues.
- (C) Direct severe distinct genetic developmental disorders or significant tragic early spontaneous pregnancy loss.
- (D) Massive rapid systemic spontaneous uncontrolled sudden extensive muscular tissue hypertrophy.

Ans : (C)

Both major types of cellular division must occur in a highly controlled manner. While distinct errors during mitosis frequently lead to uncontrolled growth and eventual tumour formation, specific faulty chromosome separation during meiosis actively results in severe genetic disorders, distinctive developmental problems, early pregnancy loss, or significantly reduced overall human fertility rates.

- 53.** Consider the strictly following specific structural scientific statements meticulously describing the central eukaryotic cellular nucleus:
1. It strictly features a highly porous, distinct continuous double-layered external protective envelope boundary.
 2. It intrinsically centrally stores totally randomly completely highly disorganized loose functional protein molecules instead of proper genetic DNA.
 3. It entirely strictly fundamentally completely functionally actively lacks any discrete internal solid central structures resembling nucleoli bodies.

4. It crucially correctly inherently strictly contains vital functional segments of highly specific DNA scientifically universally called active genes.

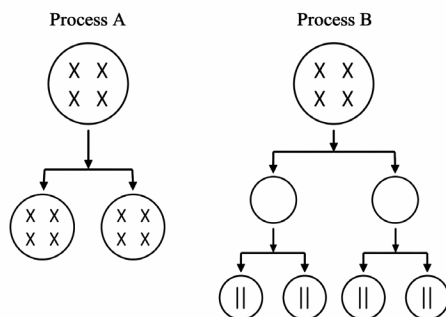
Which accurate specific combination of the above descriptive statements remains entirely factually correct?

- (A) 1 and 4 only
(B) 2 and 3 only
(C) 1, 3, and 4 only
(D) 1, 2, 3, and 4

Ans : (A)

The nucleus features a double-layered membrane with distinct pores facilitating material transfer. It houses chromosomes, consisting of genetic material combined with specialized proteins. A dense round nucleolus within synthesizes ribosomal subunits. Prokaryotic cells entirely lack this well-defined nuclear membrane, housing their genetic material in an irregular, undefined region called the nucleoid.

54. Which statement accurately describes the biological significance of the cellular division processes depicted?



- (A) Process A produces gametes for reproduction, while Process B facilitates physical growth.
(B) Process A ensures genetic stability during growth, while Process B creates gametes for reproduction.
(C) Process A occurs exclusively in reproductive organs, while Process B occurs in all body tissues.
(D) Both processes result in daughter cells that are genetically identical to the original parent cell.

Ans : (B)

Process A illustrates mitosis, producing two daughter cells with the exact same chromosome number as the parent, essential for growth and tissue repair (genetic stability). Process B illustrates meiosis, a two-step division producing four gametes with exactly half the parent's chromosome number, which is essential for sexual reproduction and genetic variation.

55. The monumental formulation of the original universally accepted foundational biological Cell Theory fundamentally permanently critically unified all complex biological sciences. Which exact distinct specific pair of extremely renowned prominent nineteenth-century biological scientists is historically entirely accurately credited with proposing this original foundational theory?

- (A) Robert Hooke and Anton van Leeuwenhoek
(B) J. Craig Venter and Arun Kumar Sharma
(C) Matthias Schleiden and Theodor Schwann
(D) Rudolf Virchow and Camillo Golgi

Ans : (C)

The foundational classical Cell Theory successfully unified all biological sciences by definitively stating that all living organisms consist of cells. This monumental conclusion was primarily formulated through the combined scientific efforts of Matthias Schleiden, a dedicated botanist studying plants, and Theodor Schwann, an observant zoologist who meticulously examined various animal tissues.

56. Although initially ground breaking, the very first original classical version of the prominent biological Cell Theory critically profoundly failed to logically properly adequately scientifically explain exactly one absolutely crucial fundamental biological developmental concept. Which prominent biological scientist finally historically successfully provided this absolutely critical missing conceptual logical piece?

- (A) Matthias Schleiden explicitly finally comprehensively proving all living dynamic plants strictly contain complex cellulose rigid cell walls.
(B) Theodor Schwann explicitly conclusively finally proving all living mobile animals strictly lack any rigid cellular external walls.
(C) Rudolf Virchow successfully explicitly definitively finally correctly stating that all new biological cells continuously arise entirely strictly from pre-existing ones.

- (D) Robert Hooke explicitly comprehensively finally successfully thoroughly discovering tiny dead rigid structural compartments located directly inside thin sections of cork.

Ans : (C)

While Schleiden and Schwann initially proposed that life is composed of cells, their original theory could not explain origin. In eighteen fifty-five, Rudolf Virchow significantly expanded their foundational work by definitively stating that all new cells arise continuously from pre-existing cells through active division, thereby brilliantly explaining the ongoing continuity of life.

57. Highly regulated, systematic cellular destruction remains essentially important for ensuring normal healthy physical development in humans. What exact technical scientific term accurately describes this deliberately programmed regulatory internal biological process?
- Accidental physical systemic sudden acute rapid tissue necrosis
 - Uncontrolled aggressive continuous cancerous spontaneous tumour formation
 - Genetically regulated intentional programmed biological selective cell death
 - Sudden uncontrolled spontaneous massive systemic tissue cellular division

Ans : (C)

Programmed Cell Death is a highly regulated, genetically controlled process of natural cellular destruction essential for maintaining healthy tissues. During typical embryonic development, it deliberately eliminates unnecessary cells. For instance, it actively removes the temporary connecting tissues between developing digits, perfectly preventing humans from being born with fully webbed fingers or toes.

58. Consider the following specific historical scientific statements carefully detailing the formulation of the widely accepted classical biological Cell Theory:
- Matthias Schleiden strictly observed that all plants are composed of cells.
 - Theodor Schwann explicitly stated that all animals are made up of cells.
 - Rudolf Virchow correctly definitively proved that all new cells exclusively continuously arise entirely from pre-existing ones.

4. Gottlieb Haberlandt explicitly proposed the original foundational concept of the unified Cell Theory entirely independently.

Which specific exact combination of the above descriptive historical statements remains scientifically and historically correct?

- 1 and 4 only
- 2 and 3 only
- 1, 2, and 3 only
- 1, 2, 3, and 4

Ans : (C)

Matthias Schleiden concluded that plants consist of cells, while Theodor Schwann stated animals are composed of cells. Rudolf Virchow significantly expanded this theory by proving new cells arise exclusively from pre-existing ones. Gottlieb Haberlandt is distinctly known for discovering plant cell totipotency, which is entirely separate from the classical cell theory.

In the year 1902, Austrian botanist Gottlieb Haberlandt proposed a remarkable biological idea that fundamentally laid the foundation for modern Plant Tissue Culture Technology. What specific extraordinary inherent biological capability of a mature plant cell did he officially propose?

- The inherent ability to completely independently rapidly generate fully functional synthetic artificial bacterial DNA sequences.
- The specialized ability to rapidly continuously naturally safely cure complex severe aggressive spreading cancerous human tumours.
- The special ability of a single mature plant cell to completely develop into an entire whole living plant.
- The unique ability to strictly completely safely naturally permanently block all targeted ongoing structural natural programmed cell death.

Ans : (C)

In nineteen-two, Austrian botanist Gottlieb Haberlandt proposed a revolutionary biological concept. He suggested that any single, fully mature living plant cell possesses the remarkable inherent ability to independently divide and completely develop into an entirely new, whole functional plant if properly provided with suitable nutrients and consistently favourable artificial laboratory conditions.

60. Arrange the following critical biological sequential stages involved in the complete typical active internal synthesis, rapid transport, and ultimate cellular secretion of a functional protein molecule in a strictly correct chronological functional order:

1. Final secretory proteins are fully securely enclosed strictly within active functional transport vesicles.
2. The complex Golgi apparatus actively carefully extensively specifically modifies, carefully structurally sorts, and completely packages the received raw proteins.
3. Dense Ribosomal functional sub-units are entirely strictly actively specifically fully continuously naturally synthesized deeply inside the central inner dense round nucleolus.
4. Active functional surface ribosomes located structurally heavily tightly directly on the rough endoplasmic reticulum specifically carefully actively heavily fully synthesize crucial raw proteins.

- (A) 2, 4, 3, 1
 (B) 3, 4, 2, 1
 (C) 3, 2, 4, 1
 (D) 4, 3, 2, 1

Ans : (B)

Protein synthesis originates in the nucleus, where ribosomal subunits are formed. These sub-units assemble into functional ribosomes often attached to the rough endoplasmic reticulum. Newly synthesized proteins travel to the Golgi apparatus for specialized packaging and modification. Finally, they are securely enclosed within vesicles for active transport or direct cellular secretion.

VERY SHORT ANSWER

61. What is the limit of resolution?

Ans :

The limit of resolution is the minimum distance between two points at which they can still be seen as distinct, separate objects.

62. Who discovered the cell and when?

Ans :

Robert Hooke was the first person to discover and observe a cell in the year 1665 by examining a thin slice of cork.

63. State one difference between a light microscope and an electron microscope.

Ans :

A light microscope uses visible light to magnify objects, whereas an electron microscope uses a beam of electrons to reveal fine structural details.

64. Why is the cell membrane called selectively permeable?

Ans :

It is called selectively permeable because it allows only certain specific substances to pass through it while completely blocking the movement of others.

65. What is the fluid-mosaic model of the cell membrane?

Ans :

The fluid-mosaic model describes the cell membrane structure as a flexible lipid bilayer with various special protein molecules embedded within it like mosaic tiles.

66. Define osmosis in the context of a cell.

Ans :

Osmosis is the net movement of water molecules through a selectively permeable cell membrane from a higher water concentration to a lower water concentration.

67. What would happen if an animal cell is placed in a hypertonic solution?

Ans :

If placed in a hypertonic solution, the animal cell will lose water to its surrounding environment through osmosis and will eventually shrink in size.

68. What is the composition of a plant cell wall?

Ans :

The plant cell wall is primarily composed of cellulose, which is a complex carbohydrate formed by many glucose units linked together for structural support.

69. What is the main function of the cell wall in plants?

Ans :

The cell wall provides rigid structural support to the plant cell, helping leaves and flowers remain

firm and withstanding environmental stresses like strong winds.

70. How is a prokaryotic cell different from a eukaryotic cell regarding the nuclear region?

Ans :

A prokaryotic cell lacks a defined nuclear membrane and features a nucleoid, while a eukaryotic cell contains a prominent nucleus perfectly enclosed by double membranes.

71. What is a nucleoid?

Ans :

A nucleoid is the specific undefined nuclear region in a prokaryotic cell that contains the genetic material as a single circular DNA molecule without membranes.

72. What is the significance of genes inside the nucleus?

Ans :

Genes are functional segments of DNA inside the nucleus that contain crucial genetic information responsible for inheriting characters from parents to next generations.

73. Name the dense round body in the nucleus and state its primary role.

Ans :

The nucleolus is the dense round body inside the nucleus where the synthesis of essential ribosomal subunits takes place before exiting into the cytoplasm.

74. Why does the rough endoplasmic reticulum appear rough under a microscope?

Ans :

The rough endoplasmic reticulum appears rough under an electron microscope because it has numerous tiny protein manufacturing structures called ribosomes securely attached to its surface.

75. State one important function of the smooth endoplasmic reticulum.

Ans :

The smooth endoplasmic reticulum plays a critical cellular role in the synthesis, processing, and effective storage of essential fats, lipids, and various important hormones.

76. What is the main result of the Golgi apparatus functioning in a cell?

Ans :

The Golgi apparatus systematically modifies, sorts, and securely packages synthesized cellular proteins and lipids into small vesicles for targeted transport, secretion, or lysosome formation.

77. Why are lysosomes commonly called the clean-up system of the cell?

Ans :

Lysosomes contain powerful digestive enzymes that effectively break down unwanted cellular waste materials, damaged cell parts, and foreign particles, keeping the cell completely clean.

78. Describe the structure of a mitochondrion in one sentence.

Ans :

A mitochondrion features a smooth, porous outer membrane and a highly folded inner membrane containing finger like projections called cristae to maximize energy production.

79. What is the scientific term for the energy currency of the cell?

Ans :

The scientific term for the major energy currency of the cell is Adenosine Triphosphate, commonly abbreviated as ATP, which fuels most cellular metabolic activities.

80. State one structural similarity between mitochondria and plastids.

Ans :

Both mitochondria and plastids uniquely possess their own specific DNA molecules and internal ribosomes, allowing them to independently synthesize some necessary structural cellular proteins.

81. What is the functional role of leucoplasts in plant cells?

Ans :

Leucoplasts are primarily colorless plastids whose main function is the bulk storage of essential food materials like starches, valuable plant oils, and crucial protein granules.

82. What causes the bright yellow or orange colors in flower petals?

Ans :

The bright yellow or orange colors frequently found in flower petals are caused by specific pigment containing plastids called chromoplasts to attract insect pollinators.

83. What is the function of the large central vacuole in mature plant cells?

Ans :

The exceptionally large central vacuole is filled with watery cell sap, storing essential nutrients while simultaneously maintaining proper internal turgor pressure for overall firmness.

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84. Give the condition under which a plant cell becomes noticeably wilted.

Ans :

A plant cell becomes extremely wilted when it absolutely does not receive enough water, causing the central vacuole to instantly lose its internal pressure.

85. What is the direct outcome of mitosis cell division?

Ans :

Mitosis directly results in the clear production of two genetically identical daughter cells, perfectly maintaining the exact same chromosome count as the parent cell.

86. Where does meiosis primarily take place in higher animals?

Ans :

In higher animals, meiosis primarily takes place exclusively within specific reproductive organs, such as the testes of males and the ovaries of fertile females.

87. What is the biological significance of meiosis in living organisms?

Ans :

Meiosis is highly significant because it purposefully reduces the total chromosome number by half to create gametes, ensuring crucial genetic variation during sexual reproduction.

88. What would you observe if normal cells lose their contact inhibition?

Ans :

If actively growing normal cells somehow lose their essential contact inhibition, you would observe them rapidly dividing uncontrollably, ultimately creating very dangerous cancerous tumor masses.

89. State one major principle formulated in the classical Cell Theory.

Ans :

One globally accepted major principle of the classical Cell Theory explicitly states that all diverse living organisms are entirely made up of fundamental biological cells.

90. What is meant by Programmed Cell Death in biological terms?

Ans :

Programmed cell death is a highly regulated genetic process of selective cellular destruction absolutely essential for normal embryonic development and maintaining optimal immune system functions.

SHORT ANSWER QUESTIONS

91. Explain the fluid mosaic model of the cell membrane.

Ans :

The fluid mosaic model describes the structure of the cell membrane as a flexible layer made of lipid molecules. It consists of a lipid bilayer with water-attracting heads facing outwards and water-repelling tails pointing inwards. Various proteins are embedded within this lipid bilayer. The molecules can move sideways, flip, and rotate, giving it a fluid nature. Since the proteins and lipids are arranged randomly like tiles, it is called a mosaic model. The proteins act as gatekeepers, helping specific substances pass through the selectively permeable membrane.

92. State the classical Cell Theory. Name the scientists who contributed to its formulation.

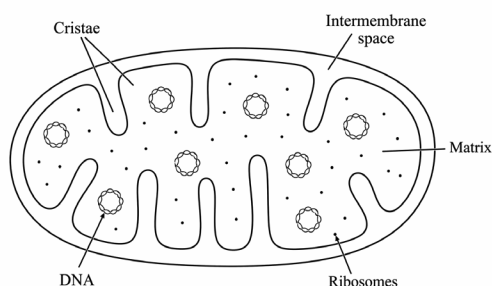
Ans :

The classical Cell Theory states that all living organisms are made up of one or more cells, and

the cell is the basic structural and functional unit of life. It also states that all new cells arise from pre-existing cells. The initial theory was proposed jointly by Matthias Schleiden, a German botanist, and Theodor Schwann, a German zoologist. Later, Rudolf Virchow expanded this theory by adding the concept that new cells are formed by the division of pre-existing cells, completing the unifying principle of biology.

93. Draw a well-labelled diagram of a mitochondrion. Explain why it is called the powerhouse of the cell.

Ans :



Mitochondria are known as the powerhouses of the cell because they generate the energy required for various cellular activities. Inside the mitochondria, glucose and other food molecules are broken down to release energy during a process called cellular respiration. This energy is captured and stored in the form of Adenosine Triphosphate molecules. The cell utilizes this stored energy currency to perform essential functions and synthesize new chemical compounds. The folded inner membrane provides a large surface area for these energy-generating chemical reactions to occur efficiently.

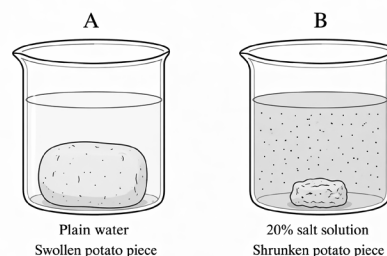
94. What is osmosis? How does it differ from diffusion?

Ans :

Osmosis is the spontaneous movement of water molecules from a region of higher water concentration to a region of lower water concentration through a selectively permeable membrane. Diffusion is the net movement of particles from an area of higher concentration to lower concentration along a concentration gradient. The primary difference is that osmosis specifically involves the movement of a solvent like water and strictly requires a selectively permeable membrane. In contrast, diffusion can occur in any

medium, such as gases or liquids, without needing any membrane.

95. Study the given experimental setup. Identify the type of solutions in Beaker A and Beaker B. Explain the reason for the change in the size of the potato pieces.



Ans :

Beaker A contains a hypotonic solution, while Beaker B contains a hypertonic solution. The potato in Beaker A swells because the water concentration outside the cell is higher than inside, causing water to move into the potato cells by osmosis. In contrast, the potato in Beaker B shrinks. The salt solution outside has a lower water concentration compared to the inside of the potato cells. Consequently, water moves out of the potato cells into the surrounding salt solution through osmosis, causing the cells to lose volume and shrink.

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96. A student claims that plant cells will burst when placed in a highly dilute medium, just like animal cells. Do you agree? Justify your answer.

Ans :

I disagree with the student's claim. While animal cells lack a rigid outer covering and will swell and eventually burst in a highly dilute medium due to excessive water intake by osmosis, plant cells behave differently. Plant cells possess a rigid, cellulose-based cell wall outside their selectively permeable cell membrane. When water enters a plant cell, the cell contents swell and exert pressure against this wall. The strong cell wall exerts an equal and opposite pressure, preventing the cell from bursting and allowing it to remain firm and turgid.

97. Compare prokaryotic and eukaryotic cells with respect to their size, nucleus, and membrane-bound organelles.

Ans :

Prokaryotic cells are generally much smaller, typically ranging from one to ten micrometers in diameter. In contrast, eukaryotic cells are larger, usually measuring between ten and one hundred micrometers. A major difference lies in their nuclear structure. Prokaryotes lack a well-defined nucleus; their genetic material lies freely in a region called the nucleoid. Eukaryotes possess a true nucleus enclosed by a double nuclear membrane. Additionally, prokaryotic cells entirely lack membrane-bound organelles, whereas eukaryotic cells contain numerous specialised membrane-bound organelles like mitochondria and the endoplasmic reticulum.

98. Explain the role of lysosomes as the clean-up system of the cell and how they manage cellular waste.

Ans :

Lysosomes function as the cellular waste disposal system by breaking down damaged organelles, foreign materials, and unwanted cellular debris. They are single membrane-bound sacs filled with highly potent digestive enzymes. When a cell accumulates waste or worn-out parts, the lysosomes engulf these materials. Their powerful enzymes then break down complex organic proteins, carbohydrates, and fats into simpler substances. These simpler products are released back into the cytoplasm for reuse. By continuously removing non-functional components, lysosomes maintain the overall health, cleanliness, and efficiency of the cell.

99. Describe the process of cell division by mitosis and mention the genetic nature of the resulting daughter cells.

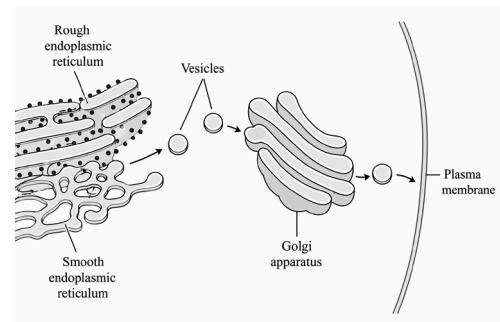
Ans :

During mitosis, a single parent cell prepares to divide by duplicating its entire genetic material. The chromatin network organizes itself into distinct, rod-shaped chromosomes containing the copied DNA. Following this preparation, the cell meticulously divides its replicated chromosomes equally between two opposite ends. Finally, the cytoplasm splits, creating two separate cells. This continuous process results in the formation of two

genetically identical daughter cells. Each new cell possesses the exact same DNA sequence and the identical number of chromosomes as the original parent cell, ensuring genetic stability.

100. Draw a labelled diagram showing the pathway for protein processing involving the endoplasmic reticulum and Golgi apparatus. How do these two organelles work together?

Ans :



The rough endoplasmic reticulum synthesizes proteins using the ribosomes attached to its surface. Once synthesized, these proteins are transported in small vesicles to the Golgi apparatus. The Golgi apparatus functions as the packaging and shipping center of the cell. It receives the proteins, modifies them, and sorts them into new vesicles. These vesicles then transport the processed proteins to their final destinations, such as the plasma membrane for secretion outside the cell or to other organelles like lysosomes for cellular use.

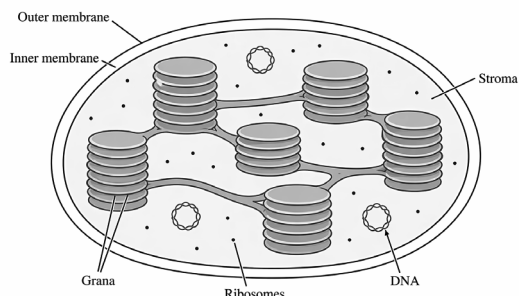
101. What would happen if a cell loses its natural contact inhibition property? Explain the consequences for a living organism.

Ans :

Contact inhibition is a natural regulatory mechanism that causes cells to stop dividing when they come into contact with neighbouring cells. If a cell loses this crucial property, it will no longer recognize signals to halt its growth. Consequently, it will continue to grow and divide uncontrollably in a rapid manner. This unrestrained cell division leads to the accumulation of abnormal cells, resulting in the formation of a mass called a tumour. In organisms, these tumours can be cancerous, aggressively invading nearby healthy tissues and spreading disease.

- 102.** Draw a labelled diagram of a chloroplast. Briefly explain its role in a plant cell.

Ans :



The chloroplast is a specialized type of plastid containing the green pigment chlorophyll. Its primary role in a plant cell is to facilitate the process of photosynthesis. The chlorophyll pigment efficiently absorbs light energy from the sun. Using this captured solar energy, along with carbon dioxide and water, the chloroplast synthesizes organic food in the form of sugars. These synthesised sugars are then temporarily stored within the stroma as starch granules, providing the essential energy required for the plant's growth and cellular activities.

- 103.** Explain the structure and function of vacuoles in mature plant cells.

Ans :

In a mature plant cell, the vacuole is a large, central sac-like structure surrounded by a single selectively permeable membrane. It is primarily filled with a watery fluid known as cell sap, which contains dissolved water, minerals, sugars, and various waste materials. This large central vacuole occupies a significant volume of the cell. Its main function is to store essential nutrients and isolate harmful waste products. Furthermore, the fluid inside exerts pressure against the cell wall, which helps maintain the structural rigidity and firmness of the entire plant.

- 104.** What are plastids? How do chromoplasts differ from leucoplasts in their content and function?

Ans :

Plastids are double-membrane organelles found exclusively in plant cells that are responsible for food synthesis and storage. They have their own

DNA and ribosomes. Chromoplasts are coloured plastids that contain pigments like yellow, orange, or red. They provide bright colours to flowers and fruits, which play a crucial role in attracting pollinators and animals for seed dispersal. In contrast, leucoplasts are completely colourless plastids lacking any pigments. Their primary function is strictly storage, accumulating essential food materials such as starch, oils, or proteins for the plant's future use.

- 105.** A student states that mitochondria and plastids can synthesize some of their own proteins independently. Is this correct? Provide scientific reasoning.

Ans :

Yes, the student's statement is scientifically correct. Both mitochondria and plastids are unique among cellular organelles because they possess their own genetic material in the form of circular DNA, as well as their own ribosomes. Ribosomes are the cellular structures responsible for protein synthesis. Because they have these two essential components, mitochondria and plastids do not have to rely entirely on the cell's nucleus and cytoplasmic ribosomes. Instead, they can independently manufacture some of the specific proteins they need to function and maintain their structures.

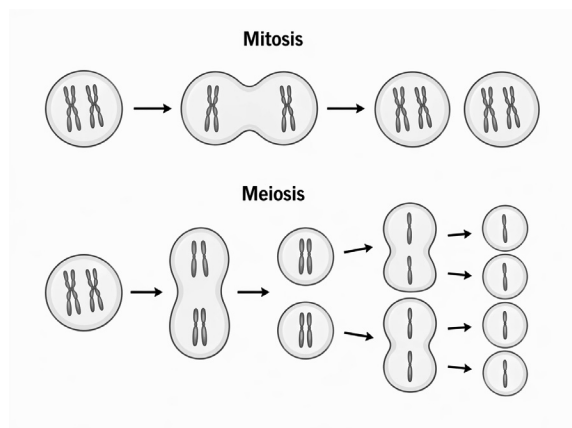
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- 106.** Compare Rough Endoplasmic Reticulum and Smooth Endoplasmic Reticulum based on their microscopic appearance and primary functions.

Ans :

Under an electron microscope, the Rough Endoplasmic Reticulum appears bumpy and rough because its surface is studded with numerous tiny structures called ribosomes. Its primary function is the active synthesis and secretion of proteins, such as digestive enzymes or hormones. Conversely, the Smooth Endoplasmic Reticulum lacks attached ribosomes, giving it a completely smooth microscopic appearance. Instead of proteins, the Smooth Endoplasmic Reticulum is chiefly involved in the vital synthesis and safe storage of essential cellular fats and lipids, which are crucial for constructing the cell membrane.

- 107.** Study the given diagram of cellular structures. Identify the type of cell division that occurs in reproductive organs. Explain how it maintains the chromosome number across generations.



Ans :

The cell division occurring in reproductive organs is meiosis. It is a two-step division process that produces four gametes, such as sperm and eggs. During meiosis, the chromosome number is halved, meaning each gamete receives only half the amount of DNA compared to the original parent cell. When a male and a female gamete fuse during the process of fertilization, the halved genetic material combines. This crucial fusion precisely restores the original, full chromosome number in the new offspring, ensuring genetic stability across successive generations.

- 108.** What is a selectively permeable membrane? Why is it important for cells rather than having a fully permeable one?

Ans :

A selectively permeable membrane is vital because it allows a cell to strictly control its internal environment by regulating what enters and exits. If the membrane were fully permeable, harmful toxins could easily flood in, and essential nutrients could freely leak out, leading to cellular death. For example, the membrane permits useful substances like oxygen and water to enter the cell while blocking large, unwanted molecules. It also ensures that toxic waste products, like carbon dioxide generated during respiration, can safely diffuse out of the cell.

- 109.** Trace and explain the path of a newly synthesized protein molecule from its origin to its secretion

outside the cell.

Ans :

The journey of a secretory protein begins at the rough endoplasmic reticulum, where attached ribosomes synthesize the protein molecule. Once manufactured, the protein is enclosed in a transport vesicle and sent to the Golgi apparatus. The Golgi receives this vesicle, chemically modifies the protein, and meticulously sorts it for its final destination. After processing, the Golgi packages the mature protein into a new secretory vesicle. This vesicle travels through the cytoplasm, fuses with the outer plasma membrane, and successfully releases the protein outside the cell.

- 110.** What is the primary function of mitochondria? What would happen to an animal cell if all its mitochondria were removed?

Ans :

If all mitochondria were removed from an animal cell, it would immediately lose its ability to perform cellular respiration. Mitochondria are the powerhouses that break down glucose to produce ATP, the essential energy currency. Without ATP, the cell would have absolutely no energy to power its vital chemical reactions, synthesize necessary molecules, or transport substances across its membrane. Consequently, all critical life processes would rapidly halt. Unable to sustain its basic metabolic functions, the animal cell would quickly cease to function and ultimately die.

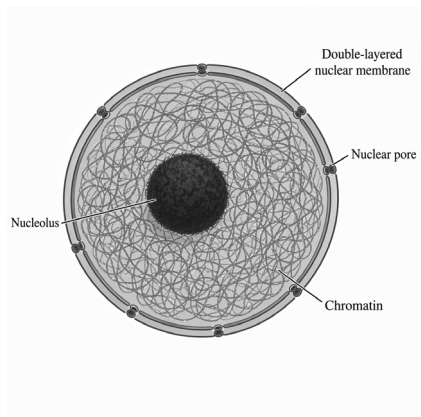
- 111.** Explain how technological interventions like the invention of electron microscopes facilitated new knowledge about cells.

Ans :

Early light microscopes were severely limited by their magnification and resolution, allowing scientists to see only basic cellular boundaries and large components. The invention of the powerful electron microscope was a major technological breakthrough. Instead of visible light, it utilizes a focused beam of electrons, allowing biologists to view structures at the nanometre scale with remarkable clarity. This high resolution revealed intricate sub-cellular details previously completely hidden, leading to the discovery and deep understanding of complex membrane-bound organelles like ribosomes, mitochondria, and the endoplasmic reticulum.

- 112.** Draw a labelled diagram showing the structure of a nucleus. What role does chromatin material play when a cell is about to divide?

Ans :



In a normal, non-dividing cell, the genetic material exists as an entangled mass of thread-like structures called chromatin material. This chromatin contains DNA which holds the vital genetic information. When a cell prepares to divide, this disorganized chromatin network begins to condense and tightly coil. It structurally reorganizes itself into distinct, thick, rod-shaped bodies known as chromosomes. This highly organized chromosomal form allows the genetic material to be easily and equally distributed to the newly forming daughter cells during the process of cell division.

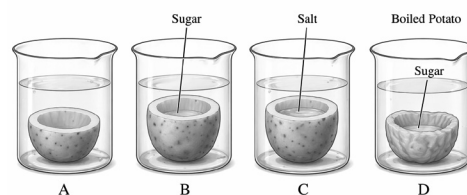
- 113.** What is a nucleoid? How does the genetic material of a prokaryotic cell differ from that of a eukaryotic cell?

Ans :

A nucleoid is an undefined, irregularly shaped region within a prokaryotic cell where the genetic material is freely suspended in the cytoplasm without any surrounding membrane. The genetic material of a prokaryotic cell consists of a single, simple circular DNA molecule associated with specific proteins. In stark contrast, a eukaryotic cell contains its complex genetic material safely enclosed within a double-layered nuclear membrane. Furthermore, eukaryotic DNA is organized into multiple, distinct, rod-shaped chromosomes rather than a single circular strand, allowing for much more complex genetic instructions.

- 114.** Draw the experimental setup to demonstrate osmosis using empty potato cups. Why is it necessary to keep one cup completely empty?

Ans :



In an osmosis experiment, it is absolutely essential to maintain one potato cup completely empty to serve as a scientific control. This empty cup provides a baseline to definitively prove that any accumulation of water in the other experimental cups is solely due to the presence of an osmotically active solute, like sugar or salt. It demonstrates that water does not spontaneously gather inside the hollowed portion on its own, thereby confirming that the movement of water is driven specifically by the concentration gradient created by the added solutes.

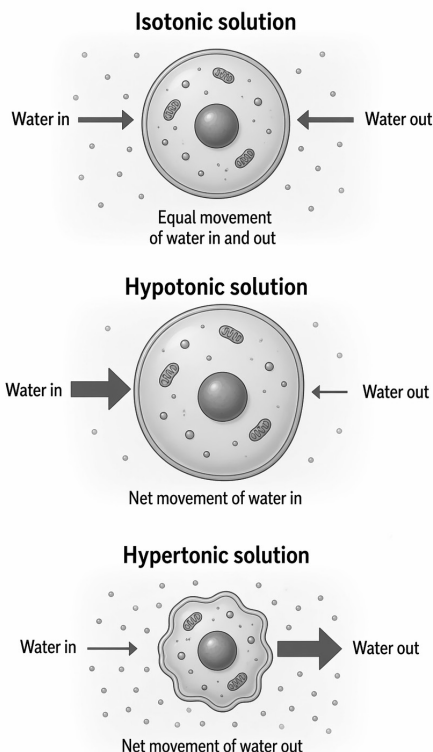
- 115.** Describe the process of Programmed Cell Death and explain its significance in the development of an organism.

Ans :

Programmed Cell Death is a genetically regulated and highly organized process of selective cellular destruction. Cells naturally execute this process when they become severely damaged, dangerously mutated, or are simply no longer required by the body. This process is absolutely essential for maintaining normal physical development, ensuring cellular quality control, and supporting proper immune function. For instance, during early embryonic development, programmed cell death selectively eliminates the unneeded tissue cells between developing digits, allowing perfectly formed, separated fingers and toes to emerge instead of webbed hands.

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116. Study the diagram showing cells in different solutions. Identify the condition under which a plant cell would experience shrinkage of its inner contents away from the cell wall. Name this specific biological process.



Ans :

A plant cell will experience the shrinkage of its inner contents when it is placed in a highly concentrated or hypertonic solution, as shown in the bottom diagram. In this environment, the external solute concentration is much higher than inside the cell, causing intracellular water to rapidly exit through osmosis. As the water leaves, the cytoplasm and cell membrane violently pull away from the rigid outer cell wall. This specific biological phenomenon, where a plant cell loses significant water and shrinks structurally, is formally known as plasmolysis.

117. What is cell culture? Why is it necessary to maintain strict sterile conditions while performing this technique?

Ans :

Cell culture is a specialized scientific method used to artificially grow plant or animal cells outside

the body under highly controlled laboratory conditions. In this technique, extracted cells are placed in a nutrient-rich medium that encourages them to safely multiply. It is absolutely critical to maintain strict sterile conditions because the nutrient medium is highly susceptible to external contamination. Any invading bacteria or unwanted fungi would aggressively compete for nutrients and rapidly destroy the cultured cells, ruining the experiment and preventing the production of vital biochemicals or medicines.

118. Why does a carrot placed in plain water stay crunchy? How does this reaction differ when placed in a salt solution?

Ans :

When a fresh carrot is placed in plain water, which is a hypotonic medium, water naturally moves into its cells via osmosis. The cells swell, exerting outward pressure against their rigid cell walls, making the entire carrot stiff and very crunchy. Conversely, a concentrated salt solution acts as a hypertonic medium. The high external salt concentration aggressively draws water out of the carrot's cells. As the cells rapidly lose water, they lose their internal turgor pressure and shrink, leaving the carrot structurally unsupported, limp, and rubbery.

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119. Your friend claims that removing the nucleus from a mature red blood cell increases its lifespan. Do you agree? Justify your answer based on cellular functions.

Ans :

I strongly disagree with the claim that lacking a nucleus increases lifespan. Mature human red blood cells naturally lack a nucleus to provide maximum internal space for packing haemoglobin, allowing them to transport larger amounts of vital oxygen. However, this beneficial adaptation comes with a severe cost. Because they completely lack a nucleus and the genetic instructions it contains, these cells cannot synthesize new proteins, repair any internal damage, or divide to replace themselves. Consequently, their lifespan is drastically shortened, allowing them to survive for only about 120 days.

- 120.** Compare plant and animal cells with respect to their outer boundaries and the size of their vacuoles.

Ans :

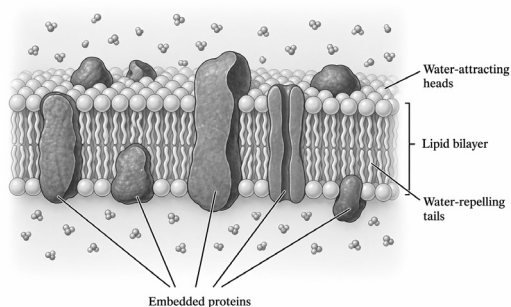
A distinct difference between plant and animal cells lies in their outer boundaries. While an animal cell is enclosed solely by a thin, flexible cell membrane, a plant cell possesses an additional rigid outer layer called the cell wall, primarily made of sturdy cellulose. This cell wall provides essential structural support against environmental stresses. Furthermore, a mature plant cell typically features a single, extremely large central vacuole that occupies most of its volume to maintain turgidity. In contrast, animal cells either lack vacuoles entirely or possess much smaller, temporary ones.

LONG ANSWER QUESTIONS

- 121.** (a) Draw a labelled diagram illustrating the fluid-mosaic model of the cell membrane?
(b) How does this structural arrangement facilitate the process of osmosis when a cell is placed in a hypotonic solution?

Ans :

(a)



- (b) This selectively permeable nature is crucial during osmosis, which is the movement of water from an area of higher water concentration to an area of lower water concentration across this membrane. When a cell is placed in a hypotonic solution, the surrounding medium has a higher water concentration than the inside of the cell. Consequently, water moves into the cell through the membrane via osmosis, causing the cell to swell and increase in overall volume.

- 122.** (a) Differentiate between prokaryotic and eukaryotic cells regarding their nuclear structure and membrane-bound organelles?
(b) What is a nucleoid?
(c) Why do mature Red Blood Cells lack a nucleus, and how does this affect their lifespan?

Ans :

- (a) Prokaryotic cells, such as bacteria, lack a well-defined nucleus and membrane-bound organelles. In contrast, eukaryotic cells have a prominent, double-membrane-bound nucleus containing chromosomes and possess several membrane-bound organelles like mitochondria and endoplasmic reticulum.
(b) Their genetic material is not enclosed by a nuclear membrane but is present as a single circular DNA molecule in a specific region of the cytoplasm known as the nucleoid.
(c) Some specialised eukaryotic cells, like mature mammalian red blood cells, are enucleate, meaning they lack a nucleus. This absence provides more internal space to accommodate a larger amount of haemoglobin, which significantly enhances their capacity to transport oxygen throughout the body. However, because they lack a nucleus and genetic instructions, these cells cannot repair themselves or divide, resulting in a short lifespan of approximately one hundred twenty days before they naturally die.

- 123.** (a) How do the rough endoplasmic reticulum and smooth endoplasmic reticulum differ in their microscopic appearance and primary cellular functions?
(b) Explain the functional relationship between the endoplasmic reticulum and the Golgi apparatus?

Ans :

- (a) The rough endoplasmic reticulum appears rough under an electron microscope because it has tiny structures called ribosomes physically attached to its outer surface, making it the primary site for protein synthesis and secretion. In contrast, the smooth endoplasmic reticulum lacks these ribosomes, giving it a smooth appearance, and is primarily responsible for the continuous synthesis and storage of fats and lipids.

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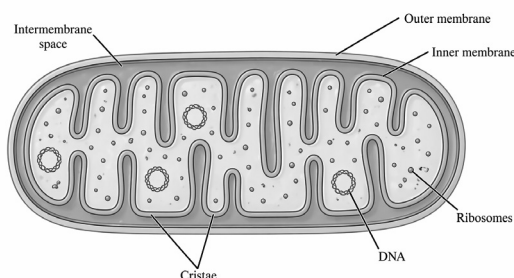
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- (b) These two distinct types of endoplasmic reticulum work in extremely close coordination with the Golgi apparatus. The Golgi apparatus consists of stacks of flattened, sac-like structures that function as the packaging and dispatch centre of the cell. Proteins and lipids synthesised in the endoplasmic reticulum are sent directly to the Golgi apparatus. Here, they are carefully modified, sorted, and packaged into small vesicles before being transported to various destinations inside or outside the cell.

124. (a) Draw a well-labelled diagram of a mitochondrion?
 (b) Why is it referred to as the powerhouse of the cell?
 (c) Mention two structural similarities between mitochondria and plastids that suggest a shared evolutionary history?

Ans :

- (a)



- (b) Mitochondria are often referred to as the powerhouses of the cell because they generate the energy required for almost all cellular activities. During cellular respiration, glucose and other molecules are broken down inside them to release energy. This energy is then stored in the form of Adenosine Triphosphate molecules, widely known as the energy currency of the cell. The cell utilises this stored energy to perform various mechanical and chemical functions.
- (c) Mitochondria and plastids, such as chloroplasts, share striking structural similarities that strongly suggest a common evolutionary history. Both of these organelles are enclosed by double membranes, possessing an outer and an inner layer. Furthermore, they both contain their own circular DNA and ribosomes. This unique characteristic enables

both mitochondria and plastids to synthesise some of their own proteins independently of the main cellular machinery.

125. (a) Define cell division and state its significance in living organisms?
 (b) How does mitosis differ from meiosis in terms of the number of daughter cells produced and their chromosome number?
 (c) What would happen if a skin cell divided by meiosis instead of mitosis?

Ans :

- (a) Cell division is the fundamental biological process through which new cells are formed from pre-existing ones, enabling physical growth, tissue repair, and reproduction in all living organisms.
- (b) Mitosis is a division process that produces two genetically identical daughter cells, each containing the exact same number of chromosomes as the parent cell. This mechanism ensures perfect genetic stability for normal body maintenance. Meiosis, however, is a two-step division restricted to reproductive organs, producing four daughter cells. Each of these gametes contains only half the number of chromosomes of the parent cell, which promotes genetic diversity during sexual reproduction.
- (c) If a skin cell divided by meiosis instead of mitosis, it would produce four cells with only half the necessary genetic material. These deficient cells would be completely non-functional, preventing the healing of wounds and critically compromising skin integrity.

126. (a) State the three main postulates of the classical Cell Theory?
 (b) What is contact inhibition in normal animal cells?
 (c) How does the failure of contact inhibition lead to the dangerous formation of tumours?

Ans :

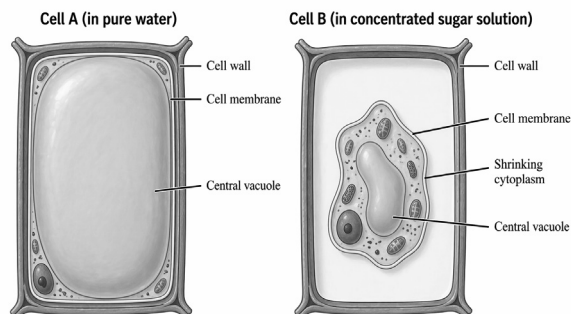
- (a) The classical Cell Theory, formulated by the scientists Schleiden, Schwann, and Virchow, states three fundamental principles. Firstly, all living organisms are entirely composed of one or more cells. Secondly, the cell represents the basic unit of structure and function in living beings. Thirdly, all new cells arise strictly from pre-existing cells through continuous cell division.

- (b) Normal animal cells strictly adhere to these principles by growing and dividing in a highly controlled, orderly manner. When these cells come into physical contact with neighbouring cells, their division usually stops. This vital regulatory mechanism is called contact inhibition, which maintains proper tissue balance.
- (c) However, when cells undergo genetic changes and become cancerous, they completely lose this contact inhibition. They ignore the natural signals from surrounding cells and continue to divide uncontrollably, eventually leading to the formation of dangerous masses called tumours.

- 127.** (a) Draw a structural diagram comparing a plant cell in pure water and a plant cell in a highly concentrated sugar solution?
- (b) Explain the mechanical role of the cell wall when the cell is placed in each of these solutions?

Ans :

(a)



- (b) The cell wall is a rigid, outermost covering in plant cells, primarily composed of cellulose, providing structural support and protection. When a plant cell is placed in pure water, which is a hypotonic solution, water continuously enters the cell through osmosis. The cell swells and builds up internal fluid pressure against the boundaries. The rigid cell wall exerts an equal and opposite pressure, preventing the swollen cell from bursting and helping it maintain a firm, turgid shape. Conversely, when the cell is placed in a highly concentrated sugar solution, which is hypertonic, it rapidly loses water due to outward osmosis. As water exits, the internal

cellular contents shrink and physically pull away from the rigid cell wall. During this shrinkage, the cell wall remains firm and retains its original shape, protecting the internal environment from complete collapse.

- 128.** (a) Contrast the size and primary function of vacuoles in mature plant cells with those found in animal cells?
- (b) Explain how lysosomes function as the waste disposal system of the cell and keep it chemically clean?

Ans :

- (a) In mature plant cells, vacuoles are extremely large, often occupying the vast majority of the internal cellular volume, and are surrounded by a selectively permeable membrane. They are permanently filled with cell sap containing water, sugars, and essential minerals, which provides crucial structural turgidity to keep the plant firm and upright. In stark contrast, animal cells either lack vacuoles entirely or possess very small ones that primarily serve for the temporary storage of materials.
- (b) Lysosomes serve an entirely different but equally crucial role as the dedicated clean-up system of the cell. They are specialized membrane-bound sacs filled with powerful digestive enzymes. During regular cellular activities, various waste materials and damaged organelles accumulate. Lysosomes fuse with these unwanted materials, and their potent enzymes break down the complex structures into simpler substances, which are subsequently released into the cytoplasm for safe reuse.

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- 129.** (a) What are plastids and in which type of organisms are they primarily found?
- (b) Categorize plastids based on the presence of pigments and mention the specific function of each category?
- (c) Why do fruits and flowers exhibit bright colours in nature?

Ans :

- (a) Plastids are specialized double-membrane organelles found exclusively in plant cells and certain algae, functioning primarily as vital centres for food synthesis and storage.

- (b) They are broadly categorized into chromoplasts and leucoplasts based entirely on their pigmentation. Chromoplasts contain various coloured pigments, while leucoplasts are entirely colourless and predominantly store essential food materials like starch, oils, or proteins, as seen in potatoes. Among chromoplasts, those containing the green pigment chlorophyll are specifically called chloroplasts, which are essential for capturing solar energy during photosynthesis.
- (c) Other chromoplasts house vibrant pigments like yellow, orange, or brilliant red. These particular pigmented plastids are abundantly present in the outer cells of flower petals and the skin of fruits. The resulting bright colours play a critical ecological role in nature by visually attracting insects and birds necessary for efficient pollination and widespread seed dispersal.

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130. (a) Who discovered cells and how did technological improvements in microscopes facilitate deeper understanding of cell structures?
- (b) Briefly describe the groundbreaking experiment conducted by J. Craig Venter in 2010 regarding synthetic biology?
- (c) Does this experiment mean scientists can create life entirely from non-living materials?

Ans :

- (a) Robert Hooke was the first person to discover cells in sixteen sixty-five while observing a thin slice of cork under a self-designed microscope. Over the centuries, significant technological advancements continually improved the magnification, resolution, and contrast of microscopes, eventually culminating in the invention of the electron microscope. These powerful electron beams allowed scientists to clearly observe intricate subcellular organelles at the nanometre scale.
- (b) In two thousand ten, scientist Craig Venter chemically synthesized an exact copy of a bacterium's entire DNA sequence in a laboratory. He inserted this synthetic DNA into another bacterial cell whose original genetic material was completely removed. The host cell successfully grew and divided based on the newly inserted synthetic instructions.

- (c) However, this remarkable experiment does not mean life was created entirely from scratch, because the necessary cytoplasm and structural cellular machinery were taken from a pre-existing living cell.

CASE BASED QUESTIONS

131. Rahul visits a science laboratory where a researcher is looking at plant cells. The researcher explains that human eyes have a limit of resolution of 0.1 mm, meaning we cannot see things smaller than that clearly. She shows Rahul a light microscope and explains that the eyepiece has a 10X magnification power and the objective lens is set to 40X. Rahul looks through it and sees tiny box-like structures. He then spots a poster showing highly detailed, nanoscale structures of a cell. The researcher says that image was taken using a different, far more powerful instrument that uses beams of electrons instead of light.

QUESTIONS:

- (a) Calculate the total magnification of the light microscope Rahul looked through.
- (b) Why is a microscope an essential tool for studying cells?
- (c) Name the more powerful instrument used to take the picture of the nanoscale details on the poster.
- (d) What is meant by the limit of resolution of the human eye?

Ans :

- (a) The total magnification of the light microscope is 400X. This is calculated by multiplying the magnification of the eyepiece (10X) by the magnification of the objective lens (40X).
- (b) A microscope is essential because most cells are much smaller than 0.1 mm, which is the limit of resolution of the unaided human eye. The microscope magnifies the image, allowing us to see these tiny structures clearly.
- (c) The more powerful instrument is the electron microscope. It uses a beam of electrons to reveal fine details at the nanometre scale.
- (d) The limit of resolution is the point at which two close objects can no longer be seen as separate distinct points by the human eye. For a normal human eye at 25 cm, this limit is about 0.1 mm.

- 132.** Meera is preparing a fresh salad for dinner. She cuts cucumbers and tomatoes into a bowl and sprinkles a generous amount of salt over them. She leaves the bowl on the kitchen counter and goes to read a book. After an hour, she returns and notices that a lot of watery liquid has collected at the bottom of the bowl, and the cucumber pieces have become soft and shrunk in size. Her mother explains that this happens due to a natural process where water moves across the selectively permeable boundaries of the vegetable cells due to the salt added on the outside.

QUESTIONS:

- Name the scientific process responsible for the release of water from the cucumber cells.
- What type of solution did the sprinkled salt create around the cucumber cells?
- How does the cell membrane act during this process?
- What would have happened to the cucumber pieces if Meera had placed them in a bowl of pure water instead of adding salt?

Ans :

- The process responsible for the release of water is osmosis.
- The sprinkled salt created a hypertonic solution outside the cells. This means the solute concentration outside was higher than the inside of the cells, causing water to move out.
- The cell membrane acts as a selectively permeable membrane. It allows water molecules to pass through it while blocking other larger or dissolved substances.
- If placed in pure water, the surrounding medium would be a hypotonic solution. Water would move into the cucumber cells by osmosis, causing them to swell and become firm.

- 133.** During a severe monsoon storm, high speed winds and heavy rainfall batter the trees in a local neighbourhood. Despite the immense pressure and stress from the harsh environment, the large trees stand tall, and their green leaves retain their shape without bursting from the excess rainwater. The next day in school, the science teacher uses this real-life event to explain how plant cells differ from animal cells. She mentions that while plants lack a bony skeleton, their cells have a special rigid outer covering. This layer provides structural support and helps them withstand

tough environmental conditions and changes in moisture.

QUESTIONS:

- Identify the special rigid outer covering present in plant cells that the teacher is referring to.
- Name the chemical substance that primarily makes up this outer layer in plants.
- If animal cells were placed in a highly dilute external environment like rainwater, they might swell and burst. Why do plant cells not burst under the same conditions?

Ans :

- The special rigid outer covering is the cell wall.
- The plant cell wall is primarily made up of cellulose, which is a complex carbohydrate that provides structural strength.
- Plant cells do not burst because the rigid cell wall exerts an opposing pressure against the swelling cell interior. This allows plant cells to withstand highly dilute (hypotonic) external media without bursting, unlike animal cells which lack this rigid wall.

- 134.** A microbiologist is examining a water sample from a hot spring under an electron microscope. She observes single-celled organisms that lack a well-defined nucleus. Their genetic material is simply present as a single circular molecule lying in a specific region of the cytoplasm. Later, she compares this with a sample of human cheek cells, which are much larger. The human cells have a distinct, large spherical structure in the center covered by a double-layered nuclear membrane, which safely houses thread-like structures containing the genetic information required for inheritance.

QUESTIONS:

- What term is used to describe the undefined nuclear region in the single-celled organisms from the hot spring?
- Based on the cell structure, classify the two types of organisms observed by the microbiologist.
- What are the thread-like structures found in the human cheek cells called, and what is their main chemical component?
- State one structural difference between the two types of cells mentioned in the passage, other than the nuclear region.

Ans :

- (a) The undefined nuclear region containing the genetic material in these simple organisms is called the nucleoid.
- (b) The single-celled organisms from the hot spring are prokaryotic cells, while the human cheek cells are eukaryotic cells.
- (c) The thread-like structures are called chromatin material or chromosomes. They are primarily composed of DNA (Deoxyribonucleic acid) and specific proteins.
- (d) Prokaryotic cells lack membrane-bound organelles, whereas eukaryotic cells have several membrane-bound organelles like mitochondria and endoplasmic reticulum.

- 135.** In a biology class, a teacher compares a eukaryotic cell to a busy manufacturing factory. She explains that one part of the cell acts as a manufacturing unit consisting of a network of tubes where proteins and lipids are synthesized. Once produced, these materials are sent to a packaging center comprising stacks of flattened sacs. Here, they are modified, sorted, and packed into small vesicles. Finally, the teacher mentions a specialized waste disposal system in the factory. This system consists of tiny membrane-bound sacs filled with powerful enzymes that break down any damaged machinery or foreign waste, keeping the cell clean.

QUESTIONS:

- (a) Identify the manufacturing unit of the cell responsible for synthesizing lipids.
- (b) Which cell organelle acts as the packaging center mentioned in the passage?
- (c) Name the waste disposal system of the cell.
- (d) Why is the rough endoplasmic reticulum considered rough, and what is its specific function?
- (e) What might happen to the cell if the waste disposal sacs accidentally burst open?

Ans :

- (a) The Smooth Endoplasmic Reticulum (SER) is responsible for the synthesis of lipids and fats.
- (b) The Golgi apparatus acts as the packaging and shipping center of the cell.
- (c) The lysosomes act as the waste disposal and clean-up system of the cell.

- (d) The rough endoplasmic reticulum looks rough under a microscope because it has tiny particles called ribosomes attached to its surface. Its specific function is protein synthesis.
- (e) If lysosomes burst open, their powerful digestive enzymes would be released into the cytoplasm and digest the cell's own organelles, ultimately leading to the destruction of the cell.

- 136.** Rohan is a marathon runner who trains for several hours every day. His coach emphasizes the importance of a proper diet to keep his stamina high. During a sports science seminar, a doctor explains that endurance athletes need highly efficient muscle cells. These muscle cells contain a large number of specific double-membrane organelles that break down glucose from food to release massive amounts of energy for cellular activities. The doctor notes that the inner membrane of this organelle is deeply folded to maximize the surface area for energy-producing chemical reactions.

QUESTIONS:

- (a) Name the cell organelle being discussed by the doctor.
- (b) What is the biological name for the deep folds of the inner membrane, and why is this folding important?
- (c) In what chemical form is the energy released and stored by this organelle?

Ans :

- (a) The organelle being discussed is the mitochondrion, often called the powerhouse of the cell.
- (b) The deep folds of the inner membrane are called cristae. This folding is important because it vastly increases the surface area available for the chemical reactions that generate energy.
- (c) The energy is released and stored in the form of ATP (Adenosine Triphosphate) molecules, which act as the energy currency of the cell.

- 137.** An agricultural scientist is studying a farm where potatoes and tomatoes are grown. She observes the bright red colour of the ripe tomatoes, which easily attracts birds and insects. She then digs up some potatoes, noting they are thick, colourless underground stems packed with starch to provide nutrition for the plant. Back in the laboratory, she explains to her intern that both the red pigments in the tomatoes and the starch storage in the potatoes are managed by the exact same category of specialized organelles, which are found exclusively in plant cells.

QUESTIONS:

- What is the general term for the category of specialized organelles mentioned by the scientist?
- Which specific type of this organelle is responsible for the bright red and orange colours of fruits like tomatoes?
- Name the specific colourless organelle that stores starch in the potatoes.
- Explain the primary function of chloroplasts, another organelle belonging to this same category.

Ans :

- The general term for these specialized organelles is plastids.
- Chromoplasts are the plastids responsible for the bright colours (other than green) in flowers and fruits.
- Leucoplasts are the colourless plastids responsible for storing food materials such as starch, oils, or proteins.
- Chloroplasts contain the green pigment chlorophyll and are responsible for synthesizing food for the plant by absorbing sunlight during the process of photosynthesis.

- 138.** Sunita goes on a family vacation for a week and forgets to ask her neighbour to water her potted indoor plants. When she returns, she finds that the plants look severely wilted, with their leaves drooping lifelessly downwards. She immediately waters them thoroughly. By the next morning, she is amazed to see that the leaves are standing firm and upright again. Her elder brother, a biology student, explains that mature plant cells have large central storage sacs filled with a fluid. The pressure from this fluid pushes against the cell boundaries, helping maintain the shape and firmness of the plant.

QUESTIONS:

- Identify the large central storage sacs in plant cells described by Sunita's brother.
- What is the watery fluid contained inside these storage sacs called?
- Explain scientifically why the plant leaves drooped when they lacked water and became firm again after watering.

Ans :

- The large central storage sacs in plant cells are called vacuoles.
- The watery fluid inside the plant vacuole is called cell sap.
- When the plant lacked water, the vacuoles lost their stored water, reducing internal pressure and causing the cells to become less firm, leading to wilting. Upon watering, the vacuoles absorbed water and swelled, restoring pressure against the cell wall and keeping the plant firm and upright.

- 139.** A young boy, Aryan, scrapes his knee badly while playing football. A thick scab forms, and after a few days, the skin completely heals as new skin cells replace the damaged ones. Around the same time, Aryan's mother gives birth to a baby girl. Aryan's grandmother comments that the new baby has eyes exactly like her father but hair like her mother. Aryan wonders how his skin can perfectly copy itself to heal his wound, while his new baby sister looks like a complex mixture of traits from both parents.

QUESTIONS:

- Which type of cell division is responsible for healing Aryan's scraped knee by replacing damaged cells?
- How does the number of chromosomes in the newly formed skin cells compare to the original skin cells?
- Name the type of cell division that produces the gametes in the parents, ultimately leading to the birth of the baby sister.
- Why does the second type of cell division result in the baby sharing traits from both parents rather than being an identical copy?

Ans :

- Mitosis is the type of cell division responsible for growth, repair, and healing of damaged tissues like Aryan's scraped knee.

- (b) In mitosis, the new daughter cells have exactly the same number of chromosomes as the original parent cell. They are genetically identical.
- (c) Meiosis is the type of cell division that occurs in reproductive organs to produce gametes (sperm and eggs).
- (d) Meiosis involves two divisions that halve the chromosome number. When a sperm and egg fuse during fertilization, the baby receives half of its genetic information from the mother and half from the father, creating genetic diversity rather than an identical copy.
- (d) Programmed Cell Death (PCD) is a genetically regulated process of selective cell destruction. It is essential for normal development, cellular quality control, maintaining balance, and immune function.
- (e) The scientists are Matthias Schleiden, Theodor Schwann, and Rudolf Virchow.

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140. Mr. Sharma recently visited a doctor for a routine check-up and discovered a small, unusual lump on his arm. The doctor performed a biopsy and explained the results using basic biological principles. He told Mr. Sharma that normal cells in the human body grow, divide, and eventually die in a highly regulated manner. They naturally stop dividing when they come into contact with neighbouring cells. However, in Mr. Sharma's lump, a few cells had lost this vital control mechanism. They ignored signals to stop growing and continued dividing uncontrollably.

QUESTIONS:

- (a) What is the medical term for the mass of abnormal cells that formed the lump on Mr. Sharma's arm?
- (b) Name the natural phenomenon where normal cells stop dividing upon coming into contact with neighbouring cells.
- (c) According to the classical Cell Theory, where do all the new cells in Mr. Sharma's body originate from?
- (d) What is Programmed Cell Death (PCD) and why is it essential for the body?
- (e) Name the three scientists whose work collectively led to the formulation of the Cell Theory.

Ans :

- (a) The mass of abnormal cells resulting from uncontrolled division is called a tumour.
- (b) The phenomenon is called contact inhibition. Normal cells show this property to prevent uncontrolled growth.
- (c) According to the Cell Theory, all new cells arise from pre-existing cells through the process of cell division.

CHAPTER 3

Tissues in Action

SUMMARY

1. WHY ARE PLANT AND ANIMAL TISSUES DIFFERENT?

1. A tissue is a group of similar cells that work together to perform a specific function.
2. Plant and animal cells group together to form distinct tissues based on their different needs.
3. Most plants are fixed in one place and need support to stay firm and upright.
4. Plant cells have a rigid cell wall that provides this necessary rigidity and strength.
5. Animals can move from place to place.
6. Animal cells lack a rigid cell wall, which allows them to change shape easily and helps in locomotion.
7. Plants have tissues that use solar energy to synthesise food through photosynthesis.
8. Animals have tissues that help them digest obtained food.
9. Plants and animals both have distinct tissues for transporting food and water.
10. The growth patterns in plants and animals vary because their tissues differ in structure and function.
11. B.G.L. Swamy was a renowned Indian botanist who made major contributions to the study of plant morphology and anatomy.

2. TISSUES FOR GROWTH IN PLANTS

1. Plants grow in length, increase in girth, and regrow after cutting or grazing.
2. This growth requires actively dividing cells in the plant body.
3. These actively dividing cells group together to form a tissue called meristematic tissue.

2.1 Apical meristem — How do plants grow in length?

1. Plant roots grow only from their tips.
2. These root tips consist of cells that divide continuously.
3. Shoot tips also contain actively dividing cells that aid in growth.
4. These growth zones at the tips of roots and shoots are called apical meristems.
5. Apical meristems help the plants grow in length.

2.2 Lateral meristem — How do plants grow in girth?

1. The stems of dicot plants increase in diameter and girth over time.
2. This growth can be seen as annual growth rings on the cut trunk of a tree.
3. Scientists can count these rings to estimate tree age and understand past climatic conditions.
4. The increase in girth is caused by actively dividing cells arranged in a ring within the stem.
5. These cells divide and produce new cells inside and outside in a concentric manner.
6. This specific meristematic tissue is called the lateral meristem.

2.3 Intercalary meristem — How do plants grow after being cut?

1. When the tip of a young stem is cut, it stops growing in length but new branches arise from the nodes.
2. A node is a point on the plant stem where branches or leaves arise.
3. The part of the stem between two nodes is called an internode.

4. Grass and hedges regrow after being mowed or grazed due to tissues located at the nodes of the stem.
5. These specific meristematic tissues are called intercalary meristems.
6. Apical meristems increase length, lateral meristems increase girth, and intercalary meristems help regeneration.
7. The cells of meristematic tissue are small, have thin cell walls, a large prominent nucleus, and dense cytoplasm.
8. Vacuoles are generally absent and the cells are tightly packed with no intercellular space.
9. These characteristics allow for continuous and rapid cell division.
10. Due to continuous division, some newly formed cells lose the ability to divide.
11. Cells that lose the ability to divide undergo changes in structure and function to become permanent tissues.
12. The process by which meristematic tissue becomes specialised to perform specific functions is called differentiation.
9. Parenchyma stores food, performs photosynthesis, and specialized types provide air spaces to help aquatic plants float.
10. Collenchyma consists of living cells with unevenly thickened corners due to pectin deposition.
11. Collenchyma provides support and flexibility, allowing parts like stems and tendrils to bend without breaking.
12. Sclerenchyma consists of dead cells with thick walls due to the deposition of lignin.
13. Sclerenchyma makes plant parts hard and strong, and is found in stems, leaf veins, seed coats, and coconut husks.
14. Conducting tissues are complex permanent tissues known as xylem and phloem, working together as vascular tissues.
15. Xylem transports water and minerals from the roots to other parts of the plant and provides strength.
16. Xylem consists of tracheids, vessels, xylem parenchyma, and xylem fibres.
17. Xylem parenchyma is the only living component of the xylem tissue.
18. Phloem transports food prepared in leaves to other parts of the plant.
19. Phloem consists mostly of living cells including sieve tubes, companion cells, and phloem parenchyma, along with dead phloem fibres.
20. Sieve tubes have perforated walls, and their cellular functions are regulated by companion cells.
21. The dermal tissue system forms the outer plant covering to protect inner parts and reduce water loss.
22. The ground tissue system forms the main body between dermal and conducting tissues, including parenchyma, collenchyma, and sclerenchyma.
23. The vascular tissue system consists of the conducting tissues xylem and phloem.
24. In older plants, outer tissues form cork cambium which divides to produce dead, compact, impermeable cork cells that form bark.
25. Scientists Sipra Guha Mukherjee and S.C. Maheshwari pioneered plant tissue culture to develop complete plants using artificial nutrient mediums.

2.4 Permanent tissues

1. Permanent tissues can be simple if composed of only one cell type, or complex if composed of multiple cell types.
2. The epidermis is a protective tissue forming the outermost single layer of flat, rectangular cells.
3. The epidermis protects the plant against mechanical injury, water loss, and invasion by parasites.
4. Epidermal cells are covered with a waxy layer called the cuticle to reduce water loss.
5. In roots, epidermal cells have projections called root hairs to increase the surface area for water and mineral absorption.
6. In leaves, the epidermis contains pores called stomata for gaseous exchange and transpiration.
7. Supporting tissues are simple permanent tissues that keep a plant upright and provide flexibility.
8. Parenchyma consists of living cells with thin walls that are loosely packed with intercellular spaces.

3. ANIMAL TISSUES

1. Animal cells also group together and specialise to perform specific functions, forming animal tissues.
2. The diversity of animal tissues allows different parts of the body to adapt and perform unique activities.
3. Animal tissues are mainly divided into four types: epithelial, connective, muscular, and nervous tissues.

3.1 Epithelial tissues — Structure and functions

1. Epithelial tissue forms the outer covering of the body, such as the skin.
2. It also lines internal organs like the mouth, lungs, blood vessels, and intestine.
3. It is composed of closely packed cells with very little space between them.
4. This tight structure prevents the entry of germs, reduces water loss, and helps in absorption and secretion.
5. Exchange epithelial tissues have a single layer of thin, flat cells for rapid diffusion of liquids and gases in blood vessels and lungs.
6. Protective epithelial tissues have many layers of tightly packed flat cells found in the skin, mouth, and oesophagus to prevent injury.
7. Secretion epithelial tissues have specialized cuboidal or columnar cells that produce mucus, enzymes, sweat, and saliva.
8. Sensory epithelial tissues have specialized receptor cells with hair-like cilia found in nostrils, taste buds, and the inner ear.
9. Absorption epithelial tissues have a single layer of tall, pillar-like cells found in the small intestine for nutrient uptake.

3.2 How are various parts connected in our body?

1. A tissue that connects and supports other tissues in the body is called a connective tissue.
2. Blood is a fluid connective tissue, while bone is a hard connective tissue.
3. They differ because blood has a watery, soft, jelly-like matrix, whereas bone has a hard, solid, and rigid matrix.
4. Blood connects parts of the body by transporting nutrients, gases, and hormones.

5. Blood is composed of 55 percent plasma and 45 percent formed elements.
6. Red Blood Cells live for about four months and contain haemoglobin, an iron-rich protein that gives blood its red colour.
7. Platelets help in blood clotting at the site of an injury.
8. White Blood Cells collect at infected areas, causing inflammation, pus formation, and fighting off infection.
9. During exercise, breathing becomes faster and blood flow increases to meet muscle oxygen demands, causing the face to turn red.
10. Bones have a rigid matrix containing calcium and phosphorus compounds that provide strength, support, and protection.
11. Cartilage has a soft, jelly-like matrix that provides flexibility and cushions the ends of bones for shock absorption.
12. Tendons are tough connective tissues that connect muscles to bones and bring about movement.
13. Ligaments connect bones to bones, provide stability, limit joint movement, and help prevent dislocation.

3.3 Can we control movement in our body?

1. Voluntary movements are actions under conscious control, such as running, writing, or lifting objects.
2. Voluntary movements are carried out by skeletal muscles.
3. Skeletal muscles are attached to the skeleton and are made of unbranched, multinucleate fibres showing light and dark striations.
4. Involuntary movements occur automatically without conscious control, such as food moving in the intestine or the heart beating.
5. Smooth muscles are responsible for involuntary movements and are found in organs like the stomach and intestines.
6. Smooth muscle cells are spindle-shaped, have a single nucleus, lack striations, and help in slow, continuous movements like digestion.
7. Cardiac muscles are found only in the heart.
8. Cardiac muscle fibres are cylindrical, branched, have a single nucleus, and display faint striations.
9. Cardiac muscles work tirelessly and rhythmically, enabling the heart to beat throughout life without fatigue.

3.4 How does the body sense, communicate and respond?

1. The nervous tissue forms the body's control and coordination network.
2. The brain acts as the control centre, coordinating activities, memory, and responses across the body.
3. Muscles cannot function independently and must receive instructions from the nervous tissue to move.
4. The cells of nervous tissue are called neurons or nerve cells.
5. Neurons are specialised to receive, process, and transmit messages.
6. A neuron has three main parts: the cell body, dendrites, and an axon.
7. The cell body contains the nucleus and controls cell activities.
8. Dendrites are branches that receive signals from other neurons.
9. The axon is a long fibre that carries messages away from the cell body to axon terminals.
10. The axon terminals transmit the messages to other cells.

4. THE MUSCULOSKELETAL SYSTEM

1. The musculoskeletal system is made up of bones, muscles, joints, cartilage, tendons, and ligaments.
2. This system helps us stand upright, move, and protects delicate internal organs.
3. The musculoskeletal system functions entirely under the control of the nervous system.
4. Muscles pull on bones to produce movement.
5. When a muscle contracts, the tendon transmits this pulling force to the bone, resulting in movement at a joint.
6. On average, the adult human skeleton makes up about 12 to 15 percent of total body weight.

4.1 The musculoskeletal system in action

1. Certain parts of the body can move easily in many directions, while others move only in a single direction.
2. A joint is a junction between two or more bones.
3. Joints allow movement, but they cannot move the bones on their own without the help of muscles.

4. The difference in how body parts move is due to the specific types of joints present at those locations.

5. TYPES OF JOINTS

Joints determine the type and range of movement possible between connected bones.

5.1 Ball and socket joint

1. The shoulder joint allows free movement of the arm forward, backward, sideways, and in a circular motion.
2. The rounded top of the upper arm bone fits into a shallow hollow of the shoulder bone to form a ball and socket joint.
3. Together with the collarbone, the shoulder blade forms the shoulder girdle, connecting the arm to the skeleton.

5.2 Hinge joint

1. A hinge joint bends and straightens in only one direction, just like a door hinge.
2. The elbow contains a hinge joint that allows the forearm to move up and down.
3. A similar hinge joint is present in the knee.
4. The knee joint is protected by a small bone called the kneecap.

5.3 Pivot joint

1. A pivot joint allows the head to move side to side freely, similar to a doorknob turning in its socket.
2. The skull is connected to the backbone through a pivot joint located at the back of the neck.

5.4 Fixed joints

1. The skull is a hard case of flat bones joined together to protect the brain, eyes, and ears.
2. The bones of the skull are connected by fixed joints, meaning the bones cannot move.
3. This fixed structure keeps the brain safe even when the rest of the body is moving rapidly.
4. Stem cells located in the bone marrow can divide and make new cells.
5. These stem cells can be transplanted to treat patients with blood disorders like Leukemia and Thalassemia.

6. SKELETAL SYSTEM

1. The skeletal system consists of a framework of bones that provides strength and protects delicate internal organs.
2. It includes the skull, the vertebral column, and the rib cage.
3. The backbone, or vertebral column, is a flexible column of small bones called vertebrae that extends from the base of the skull.
4. The vertebral column supports the body and helps humans stand upright.
5. Between each vertebra is a cartilage disc that acts as a cushion and allows flexibility for bending and twisting.
6. The rib cage consists of 12 pairs of ribs joined together to protect vital organs like the heart and lungs.
7. Ribs are attached to the spine at the back and to the breastbone in the front.
8. They are joined by flexible cartilage that allows the rib cage to expand and contract during breathing.
9. Maintaining correct posture, nutrition, regular exercise, and yoga keeps bones strong and joints flexible.
10. Scientist F.C. Steward demonstrated a concept called totipotency using carrot phloem cells.
11. Totipotency is the ability of a single mature plant cell to divide, dedifferentiate, and redifferentiate into an entire new plant.
12. Plant pathologists study a condition called crown gall disease, which causes tumours on plant stems due to rapid cell division.
13. This disease is caused by the bacterium *Agrobacterium tumefaciens*.
14. Scientists now use this bacterium as a tool in genetic engineering to introduce useful genes into plants for crop improvement.

PAUSE AND PONDER

1. You may have noticed that fibres of coconut husk are hard and brittle, whereas the leaf stalks of coriander are soft and flexible. Find out the reason.

Ans :

The difference in texture and flexibility is due to the distinct types of simple permanent tissues present in them. The fibres of a coconut husk are made of sclerenchyma tissue, which consists of dead cells with thick, lignified walls that make them hard and brittle. In contrast, the leaf stalks of coriander contain collenchyma tissue, which consists of living cells with unevenly thickened corners that provide mechanical support along with flexibility.

2. Why do you think that a thick cuticle on the outer wall of epidermis is advantageous for a plant living in the desert but disadvantageous for a plant living underwater?

Ans :

A thick cuticle is highly advantageous for a desert plant because it acts as a waterproof waxy layer that significantly reduces water loss through transpiration in hot, dry environments. However, this same thick cuticle would be disadvantageous for an underwater plant. Aquatic plants do not face the risk of dehydration and need to easily exchange dissolved gases directly with the surrounding water, a process that a thick waxy layer would obstruct. Therefore, an aquatic plant benefits from having little to no cuticle to facilitate efficient diffusion.

3. Once water is absorbed by plant roots, it has to travel against gravity through xylem. How do the 'dead' cells of the xylem work together with the living cells of leaves at the top to keep the water moving?

Ans :

The dead tubular cells of the xylem, such as tracheids and vessels, act as continuous physical pipes that allow water to flow upwards from the roots. The living cells in the leaves contribute to this process by losing water through stomata in a process called transpiration. This evaporation from the leaves creates a suction force, or transpiration pull, which continuously draws the column of water up through the dead, thick-walled xylem vessels against the force of gravity. Thus, the living leaf cells provide the pulling force while the dead xylem cells provide the necessary structural pathway.

4. What do you think will happen if there were no stomata in the epidermis of the stem or leaves?

Ans :

If there were no stomata in the epidermis, the plant would be unable to perform gaseous exchange, thereby halting the critical processes of photosynthesis and respiration. Furthermore, without stomata, transpiration could not occur, meaning the plant could not generate the transpiration pull required to transport water and minerals upward from the roots.

5. Look at the picture given below. Carefully observe the various poses of classical and folk dances of India. Can you identify which joints are involved? Also, what type of movement each joint allows?



Ans :

The dancers use several distinct joints to achieve these dynamic poses. The ball and socket joints in the shoulders and hips are highly involved, allowing for forward, backward, sideways, and circular movements of the arms and legs. The hinge joints in the elbows, knees, and ankles permit the bending and straightening of limbs in a single direction, while the pivot joint in the neck allows the head to smoothly move from side to side.

NCERT EXERCISE

1. Meristematic tissues divide repeatedly. What property of their cells allows them to do this?
- They have thick walls for protection.
 - They contain large vacuoles that store nutrients.
 - They have thin walls, dense cytoplasm and large prominent nucleus.
 - They are functionally differentiated cells.

Ans :

(iii) They have thin walls, dense cytoplasm and large prominent nucleus.

Meristematic cells are actively dividing, requiring thin walls for easy division, dense cytoplasm to support high metabolic rates, and a large nucleus to coordinate continuous cell cycles, while lacking large vacuoles that would hinder division.

2. If a plant is unable to transport food from leaves to roots which tissue is malfunctioning?
- Xylem
 - Phloem
 - Epidermis
 - Sclerenchyma

Ans :

(ii) Phloem

Phloem is the complex permanent conducting tissue specifically responsible for transporting the food prepared in the leaves to all other parts of the plant, including the roots.

3. Why are the epithelial tissues that line an animal's internal organs usually only one or a few cells thick?
- To store food efficiently.
 - To provide maximum strength.
 - To allow quick exchange of materials across them.
 - To reduce friction.

Ans :

(iii) To allow quick exchange of materials across them.

A thin layer of epithelial cells minimizes the distance for diffusion, facilitating the rapid and efficient exchange of gases, nutrients, and waste products across the lining of internal organs like blood vessels and alveoli.

4. You can perform these two jumps as show in figure



Straight-leg jump — keep knees and ankles stiff.
Normal jump — bend knees and ankles naturally.
How did your ankle, knee and hip positions differ between the two jumps?

Ans :

In the straight-leg jump, the joints at the ankle, knee, and hip are kept rigid and fully extended, preventing the bending required to absorb shock and generate upward force efficiently. In the normal jump, the ankle, knee, and hip joints undergo a coordinated bending (flexion) during the preparatory phase and rapid straightening (extension) to push off the ground. The normal jump utilizes the hinge joints in the knees and the flexibility of the ankles and hips to act like springs for better movement.

5. Which type of joint is involved when you bend your knees and ankles?
- Ball and socket
 - Hinge
 - Pivot

Ans :

- (ii) Hinge

The knee and ankle joints function primarily as hinge joints, allowing movement back and forth in predominantly one plane (bending and straightening), similar to the opening and closing mechanism of a door.

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6. In each of the following cases (A, B, C and D), choose the correct option as given below:
- Both (A) and (R) are true, and (R) is the correct explanation of (A).
 - Both (A) and (R) are true, but (R) is not the correct explanation of (A).
 - (A) is true, but (R) is false.
 - (A) is false, but (R) is true.

- A. Assertion: Epithelium is well-suited for gas exchange in the lungs.

Reason: It consists of multiple layers of tall cells that slow down diffusion.

Ans :

- (iii) (A) is true, but (R) is false.

The epithelium in the lungs (alveoli) is well-suited for gas exchange because it consists of a single, thin layer of flat cells, not multiple layers of tall cells, which would indeed slow down diffusion.

- B. Assertion: Cardiac muscle can contract continuously without fatigue.

Reason: Cardiac muscle cells have a high number of mitochondria and an abundant blood supply.

Ans :

- (i) Both (A) and (R) are true, and (R) is the correct explanation of (A).

Cardiac muscles work tirelessly throughout life, and this continuous rhythmic contraction requires immense energy, which is continuously provided by numerous mitochondria and sustained by a rich blood supply delivering constant oxygen and nutrients.

- C. Assertion: Tendons connect bone to bone and allow joint movement.

Reason: Tendons are made of tough connective tissue that transmits force from muscle to bone.

Ans :

- (iv) (A) is false, but (R) is true.

The assertion is false because tendons connect muscles to bones, whereas ligaments connect bone to bone. The reason is a true statement describing the composition and function of tendons in facilitating movement.

- D. Assertion: In a hinge joint, movement occurs primarily in one plane.

Reason: The bone ends are shaped to allow sliding in all directions.

Ans :

- (iii) (A) is true, but (R) is false.

A hinge joint restricts movement to one plane (bending and straightening). The reason is false because bone ends in a hinge joint are shaped to interlock and allow motion in only one direction, not sliding in all directions like a ball and socket joint.

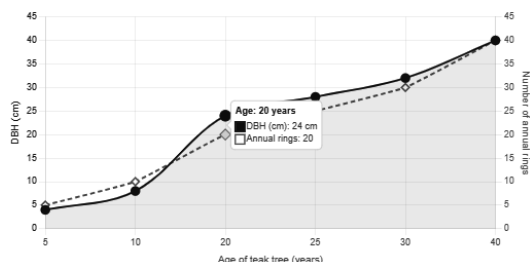
7. Plot a graph between the age of a tree (in years) on the x-axis and the diameter of the tree (in cm) along with the number of annual rings formed over time on the y-axis, using the data given in the Table.

S. No.	Age of Teak Tree (Years)	DBH (cm)	Number of Annual Rings
1	5	4	5
2	10	8	10
3	20	24	20
4	25	28	25
5	30	32	30
6	40	40	40

- (i) Analyse the graph in terms of the diameter of the stem over time and share the interpretation.
- (ii) What is the relation between the diameter of the teak tree to the annual rings formed?
- (iii) Which specialised tissue is responsible for the girth of the stem and where is it located?

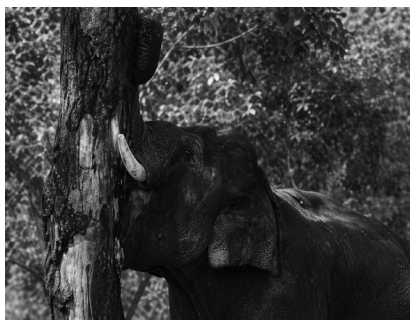
Ans :

- (i)



- (ii) There is a direct proportionality between the diameter of the teak tree and the number of annual rings formed. As the number of annual rings increases (representing each year of growth), the diameter of the tree correspondingly increases, demonstrating that each ring adds a new layer to the tree's overall girth.
- (iii) The lateral meristem is the specialised tissue responsible for increasing the girth or diameter of the stem. It is located along the circumference of the stems and roots, forming concentric rings of actively dividing cells.

8. In a forest, it was observed that one of the trees was severely debarked by an elephant to meet its food requirements, as the bark is a rich source of nutrients Figure. Based on your learning, answer the following:



- (i) Which function(s) of the tree is/are hampered by debarking?
- (ii) Which plant tissue would be affected by further damage to the tree trunk even after debarking?

- (iii) Which function of the tree would be hampered if the tissues beneath the bark were severely damaged?
- (iv) What assumptions are you making to answer the questions above? How would the answer change if your assumptions are also changed?

Ans :

- (i) Debarking removes the outer protective epidermal/cork layers and the inner phloem tissue. This severely hampers the tree's protective function against water loss, mechanical injury, and infections. More critically, the removal of phloem disrupts the downward transport of food produced in the leaves to the roots and lower trunk.
- (ii) Further damage to the deeper layers of the tree trunk after the outer bark and phloem are removed would affect the xylem tissue, which constitutes the woody core of the trunk.
- (iii) If the xylem tissues lying beneath the bark were severely damaged, the upward transport of water and dissolved minerals from the roots to the leaves would be hampered. This would quickly lead to wilting and the inability of leaves to perform photosynthesis.
- (iv) The primary assumption made is that debarking removes the complete ring of outer bark and the underlying living phloem tissue (girdling), while leaving the deeper xylem intact initially. If the assumption is changed to mean only superficial dead cork cells were scraped off without damaging the phloem, then food transport would not be hampered, and the tree could heal. If the assumption is that the damage was deep enough to sever both phloem and xylem simultaneously, then both food and water transport would instantly stop, causing rapid death of the entire plant.

Aamrapali observed that a young mango sapling's stem bends flexibly during monsoon winds and does not break. Which tissue is responsible for this flexibility? Predict and provide your explanation of the impact if the existing tissue was replaced by sclerenchyma.

Ans :

The collenchyma tissue is responsible for the flexibility observed in the young mango sapling's stem, allowing it to bend under stress without breaking. If the collenchyma were replaced by sclerenchyma, the stem would lose its elasticity

and become completely hard, rigid, and brittle. Under the strong force of monsoon winds, the stiff stem would be unable to bend and would likely snap and break, because sclerenchyma provides rigid mechanical support due to its thick lignified walls, lacking the flexible nature of collenchyma.

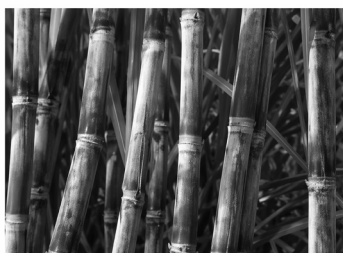
10. Sohan designed an experiment for the regeneration of sugarcane, where he used cuttings to grow sugarcane. He used two types of cuttings, type 'A' and type 'B'. After a few weeks, type 'B' cuttings sprouted and developed into sugarcane plants, whereas the type 'A' cuttings did not sprout.



(A)



(B)



- Why were the type 'B' cuttings able to grow as sugarcane but type 'A' could not?
- What difference was present in type 'B' compared to type 'A'?
- What observation or measurement was made to determine whether this change had an effect?
- What parameters should be kept the same for both types of cuttings to ensure a fair comparison?

Ans :

- Based on the visual reference in figure, type 'B' cuttings contain nodes, whereas type 'A' cuttings are only internodal sections. Type 'B' cuttings were able to grow because the nodes contain intercalary meristematic tissues, whose actively dividing cells are essential for sprouting new shoots and roots. Type 'A' could not grow as it lacked these meristematic regions.
- The crucial structural difference is the presence of nodes (the joint-like structures) in type 'B' cuttings and their absence in type 'A' cuttings. These nodes house the intercalary meristem necessary for regeneration.

- The primary observation made to determine the effect was visually checking whether the planted cuttings sprouted new shoots and developed into visible sugarcane plants after a period of a few weeks.
- To ensure a fair scientific comparison, external growth parameters such as soil type, moisture level, amount of sunlight, ambient temperature, and the source plant's age and health should be kept identical for both type 'A' and type 'B' cuttings.

11. During the discussion in class, Rohan gives a statement that, "A tissue is a group of similar cells performing similar functions". But Rajiv counter argues that, "this is true in case of simple tissues but little different in case of complex tissues". Provide your explanation in view of the discussion in class.

Ans :

Rajiv's counter-argument is scientifically correct. Rohan's definition perfectly describes simple tissues, such as parenchyma or epithelial tissue, where all constituent cells are structurally similar and carry out identical functions. However, complex tissues in plants, like xylem and phloem, are composed of more than one distinct type of cell that work together as a cohesive unit to perform a common overall function. For example, xylem consists of structurally different tracheids, vessels, parenchyma, and fibres that all coordinate to transport water, making the definition of a tissue broader when considering complex types.

12. Coconut husk fibres are used for mats which are tough and fibrous. Which tissue has structural features suitable for providing this strength? Explain why living parenchyma couldn't serve the same purpose.

Ans :

Sclerenchyma tissue has the structural features suitable for providing the tough, fibrous strength seen in coconut husks. Its cells are dead, long, and have exceptionally thick walls due to the heavy deposition of lignin, making them rigid and strong. Living parenchyma could not serve this purpose because its cells have thin walls made only of cellulose, remain soft, and are structurally adapted for functions like food storage and photosynthesis rather than providing high tensile mechanical strength.

13. Vibha claims to her friend Neha that, “Meristematic cells are located only at the root and shoot apices”. What do you think about this statement? What question can Neha ask Vibha to help her understand further if the statement is incorrect?

Ans :

Vibha’s statement is incorrect because meristematic tissues are not restricted only to the tips of roots and shoots. They are also found as lateral meristems (cambium) along the sides of stems and roots, and as intercalary meristems at the nodes or bases of leaves. To help Vibha realize this, Neha could ask: “If meristematic cells are only at the very tips for increasing length, which cells are responsible for a tree trunk growing wider in girth over the years, or how does a lawn grass regrow its leaves after being mowed from the middle?”

14. A plant cell and an animal cell are of the same size.
- Which cell will have a larger vacuole? Give reasons.
 - What assumptions are you making to answer the question above?

Ans :

- The plant cell will have a significantly larger vacuole. Plant cells typically feature a single, large central vacuole that can occupy most of the cell’s volume to store water, essential nutrients, and waste products, while also providing necessary turgidity to maintain the plant’s rigid structure. In contrast, animal cells either lack vacuoles entirely or have very small, temporary ones.
 - The primary assumption made is that we are comparing a mature, fully differentiated plant cell (like a typical parenchyma cell) with a standard mature animal cell. Young meristematic plant cells might have smaller vacuoles resembling animal cells, so the generalization assumes typical adult cell structures.
15. A textbook states, “Each plant tissue performs only one specific function”. What questions would you ask to critically examine the correctness of this statement? What examples of tissues would you take to find out the answers to these questions?

Ans :

To critically examine this statement, I would ask: “Can a specific plant tissue adapt to perform multiple physiological roles depending on its location in the plant body?” and “Do basic tissues have specialized variations that handle completely different tasks?” To find the answers, I would examine parenchyma tissue. While basic parenchyma primarily stores food, specialized parenchyma in leaves contains chlorophyll to perform photosynthesis (chlorenchyma), and in aquatic plants, it develops large air spaces to provide buoyancy (aerenchyma). This demonstrates that a single fundamental tissue category can be modified to perform several entirely distinct and specific functions, proving the textbook statement incorrect.

OBJECTIVE QUESTIONS

- The structural organisation of organs and organ systems is highly complex in multicellular organisms. Which of the following defines a tissue in this biological hierarchy?
 - A group of cells having different origins but performing a similar function
 - A group of cells similar in structure that work together to perform a specific function
 - An isolated group of cells that operate independently to sustain the life of an organism
 - A collection of different cell types randomly distributed throughout the body

Ans : (B)

A tissue is fundamentally defined as a group of cells possessing a similar structure that work in a coordinated manner to perform a highly specific function. This coordinated grouping creates a division of labour, which significantly increases the overall functional efficiency within the body of a complex multicellular organism.

Plants and animals possess distinct types of tissues due to their different lifestyle patterns. Which primary factor necessitates the presence of diverse tissue structures in these two groups?

- The mechanism of cellular respiration required for energy
- The fundamental difference in their overall physical mobility

- (C) The variation in the amount of water required for survival
 (D) The difference in atmospheric oxygen and carbon dioxide usage

Ans : (B)

The primary structural difference between plants and animals relates directly to their mobility. Animals require specialized tissues for movement and locomotion to seek food. In contrast, plants are strictly stationary organisms requiring rigid structural support tissues to remain upright, which heavily influences their distinct cellular and tissue-level organizational patterns.

3. Identify the specific type of meristematic tissue present at the region marked 'X' that allows the plant to produce new branches or leaves from this point.



- (A) Apical meristem
 (B) Lateral meristem
 (C) Intercalary meristem
 (D) Secondary meristem

Ans : (C)

Intercalary meristems are actively dividing tissues located specifically at the nodes of stems or the base of leaves. They are responsible for the localized growth of internodes, enabling the plant to produce new branches or regenerate parts after grazing. Apical meristems increase overall length, while lateral meristems increase stem girth.

4. Growth in plants is restricted to specific regions, unlike the relatively uniform growth seen in animals. Which specific tissue is directly responsible for the localized growth observed in plants?
- (A) Simple permanent tissue
 (B) Complex permanent tissue
 (C) Meristematic tissue
 (D) Epidermal tissue

Ans : (C)

Meristematic tissue is specifically responsible for the growth occurring in plants. These particular tissues consist of actively and continuously dividing cells localized in specific growing regions, such as the tips of roots and shoots. This localized cellular division facilitates the continuous physical expansion and growth of the plant body.

5. An experiment is conducted to observe the growth of onion roots. Read the experimental steps provided below and select the correct chronological sequence of the procedure.
1. Measure the length of roots for the first three days.
 2. Place two onion bulbs in separate water-filled jars.
 3. Observe the growth of roots in both bulbs for a few days.
 4. Cut the root tips of the bulb in the second jar on day three.
 5. Measure the root lengths for four more consecutive days.
- (A) 2, 3, 1, 4, 5
 (B) 1, 2, 4, 3, 5
 (C) 2, 1, 3, 5, 4
 (D) 3, 2, 1, 4, 5

Ans : (A)

To properly observe root growth, the bulbs must first be placed in jars. General observation follows, after which daily measurements are recorded for three days. The crucial experimental variable is introduced by cutting the root tips on day three, followed by subsequent measurements to compare the ongoing growth patterns accurately.

6. The stems of dicot plants undergo an increase in diameter or girth over time, leading to the formation of wood. Which specific tissue is responsible for this lateral expansion?
- (A) Apical meristem
 (B) Intercalary meristem
 (C) Lateral meristem
 (D) Primary permanent tissue

Ans : (C)

The lateral meristem is the actively dividing tissue located along the circumference of plant stems and roots. Its cellular division produces new cells in a concentric manner, which directly causes the plant stem or root to continuously increase in girth or diameter over time, leading to secondary growth processes.

7. Consider the following statements regarding the intercalary meristem found in certain plant species:

1. It is primarily responsible for the vertical growth of roots deep into the soil.
2. It is situated at the base of leaves or internodes on plant stems.
3. It allows grasses to regenerate successfully after being grazed by herbivores.

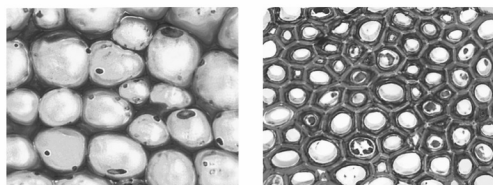
Which of the above statements are correct?

- (A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 1, 2, and 3

Ans : (B)

The intercalary meristem is located at the base of internodes or leaves, rather than at root tips. It plays a crucial role in enabling certain plants, especially grasses, to regenerate and grow rapidly after parts of the plant have been cut off or consumed by various grazing herbivorous animals.

8. The given micrographs display two types of supporting tissues found in plants. Which structural feature primarily differentiates Tissue P from Tissue Q?



Tissue P

Tissue Q

- (A) Tissue P has uniformly thickened walls, whereas Tissue Q has thin cell walls.
(B) Tissue P has unevenly thickened corners due to pectin, whereas Tissue Q has thick lignified walls.
(C) Tissue P contains large intercellular spaces, whereas Tissue Q is tightly packed.
(D) Tissue P consists entirely of dead cells, whereas Tissue Q consists of living cells.

Ans : (B)

Tissue P represents collenchyma, which provides mechanical support and flexibility through living cells featuring unevenly thickened corners caused by pectin deposition. Conversely, Tissue Q represents sclerenchyma, which provides rigid structural strength using dead cells encased in thick, lignified walls. Parenchyma tissues

typically feature noticeable intercellular spaces and uniformly thin walls.

9. Based on the experimental growth data of two plant specimens, which conclusion regarding the tissue responsible for plant elongation is most accurate?

Day	Root X Length (cm)	Root Y Length (cm)
Day 1	1.0	1.0
Day 2	1.5	1.5
Day 3 (Terminal tip of Root Y removed)	2.0	2.0
Day 4	2.6	2.0
Day 5	3.3	2.0

- (A) The elongating tissue transitions into permanent protective tissue within exactly three days.
(B) The actively dividing cells responsible for longitudinal growth are located exclusively at the root apex.
(C) The root tip primarily contains lateral meristems that continuously increase the overall root girth.
(D) The physical removal of the root tip prevents further water absorption but allows continuous cellular expansion.

Ans : (B)

The provided table demonstrates that Root X continues elongating steadily, whereas Root Y stops growing entirely after its terminal tip is removed on Day 3. This comparative data clearly indicates that the actively dividing cells responsible for longitudinal growth are located exclusively at the root apex, forming the crucial apical meristem.

10. **Assertion (A):** The cells of meristematic tissues generally lack vacuoles.

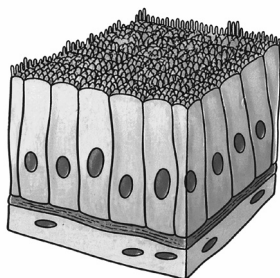
Reason (R): Vacuoles are primarily responsible for storing sap and providing rigidity, which is not required by actively dividing cells.

- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Meristematic cells continuously divide and require a dense cytoplasm rather than storage structures. Vacuoles store cellular sap and provide structural rigidity to mature plant cells. Such rigidity and large volume occupancy would significantly hinder the rapid and continuous cellular division processes required within active meristematic zones of the plant.

11. The illustrated tissue lines the inner surface of the small intestine. How does its pillar-like structure directly support its biological function?



- (A) It provides rigid mechanical support against friction during the passage of food.
 (B) It facilitates rapid diffusion of gases across a single thin layer of cells.
 (C) It ensures maximum surface area for the efficient absorption of digested nutrients.
 (D) It actively secretes hormones directly into the bloodstream for digestion.

Ans : (C)

The tall, columnar structure of this epithelial tissue is specifically adapted for efficient absorption and secretion. Found prominently lining the inner walls of the small intestine, these elongated cells maximize the available surface area, thereby facilitating the rapid and effective uptake of digested nutrients, water, and essential minerals into the body.

12. In multicellular organisms, there is a specific hierarchy of biological organization that ensures division of labour. Arrange the following levels in the correct developmental sequence from simplest to most complex.
1. Organ
 2. Tissue
 3. Cell
 4. Organism
 5. Organ system
- (A) 3, 2, 1, 5, 4
 (B) 2, 3, 1, 5, 4

(C) 3, 1, 2, 4, 5

(D) 3, 2, 5, 1, 4

Ans : (A)

The fundamental building block of all living structures is the cell. Groups of similar cells organize to form a specific tissue. Various tissues combine structurally to form an organ. Multiple organs function together cooperatively as an organ system, and all systems combined constitute the complete, functioning multicellular living organism.

13. As newly formed plant cells mature, they undergo a specific biological process to become permanent tissues. What is the correct term for the process by which cells take up a permanent shape, size, and function?
- (A) Multiplication
 (B) Differentiation
 (C) Elongation
 (D) Regeneration

Ans : (B)

Differentiation is the specialized process by which actively dividing meristematic cells gradually lose their ability to divide. These cells then undergo structural changes to adopt a specific permanent shape, distinct size, and dedicated physiological function, ultimately transforming into various types of highly specialized permanent tissues within the plant body.

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14. Meristematic cells exhibit specific structural characteristics that enable them to perform their continuous division. Which of the following is not a characteristic feature of meristematic tissue cells?
- (A) They possess a large and prominent nucleus.
 (B) They contain very dense cytoplasm.
 (C) They have thick, heavily lignified cell walls.
 (D) They generally lack large intercellular spaces.

Ans : (C)

Cells constituting meristematic tissue are required to divide rapidly and continuously. Therefore, they inherently possess very thin cellulosic cell walls that facilitate division. Thick, heavily lignified cell walls are a characteristic feature of dead structural tissues like sclerenchyma, which primarily provide mechanical strength rather than facilitating active cellular division.

15. Read the following statements concerning the epidermis in plants:

1. It is usually composed of a tightly packed, single layer of cells.
2. It actively conducts water and dissolved minerals from the roots.
3. It secretes a waxy, water-resistant layer called the cuticle.

Which of the statements given above are correct?

- (A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 1, 2, and 3

Ans : (C)

The epidermis forms the outermost protective cellular layer of the plant body, usually consisting of a single tightly packed cell layer. It actively secretes the waxy cuticle to prevent water loss. However, it does not conduct water internally; that specific transport function is exclusively performed by the complex vascular xylem.

16. The epidermis of a leaf contains small microscopic pores essential for its physiological functions. What are these pores called, and what is their primary function?

- (A) Lenticels; required solely for the release of excess water
(B) Stomata; required for gaseous exchange and transpiration
(C) Hydathodes; responsible for secreting plant hormones
(D) Cuticles; responsible for absorbing sunlight for photosynthesis

Ans : (B)

Stomata are the tiny microscopic pores present within the epidermal layer of plant leaves. They are absolutely essential for regulating the exchange of carbon dioxide and oxygen gases with the atmosphere. Furthermore, they facilitate transpiration, which is the vital process of water vapor evaporation from the internal plant tissues.

17. Desert plants survive in extremely arid conditions where water conservation is critical. What specialized structural adaptation is predominantly found in the epidermal layer of these plants?

- (A) A thick layer of cutin on the outer surface
(B) An abundance of large, permanently open stomata
(C) A complete absence of an epidermal cell layer
(D) An extremely thin and highly permeable cell wall

Ans : (A)

Plants inhabiting extreme desert environments face severe water scarcity. To combat excessive dehydration, their epidermal cells secrete an unusually thick coating of cutin. This chemical substance forms a robust waterproof cuticle layer over the plant exterior, significantly reducing the critical rate of water loss through the process of transpiration.

18. Match the plant tissues in List-I with their corresponding prominent structural features or functions in List-II.

	List-I (Tissue Type)		List-II (Feature/Function)
P.	Parenchyma	1.	Cells have unevenly thickened corners due to pectin
Q.	Collenchyma	2.	Forms the protective outer single-layered covering
R.	Sclerenchyma	3.	Cells are dead with thick lignified walls
S.	Epidermis	4.	Loosely packed living cells that store food

- (A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-4, S-3

Ans : (A)

Parenchyma cells are living and loosely packed to store food. Collenchyma cells provide flexibility due to localized pectin deposition at cell corners. Sclerenchyma provides hard structural support using dead, heavily lignified cells. The epidermis functions as the single-layered outermost protective barrier covering all the external surfaces of the plant body.

Analyze the following characteristics related to a specific simple permanent plant tissue:

1. It consists of living cells with relatively thin cell walls.
2. The cells are loosely packed, possessing intercellular spaces.
3. It primarily functions to store food materials.
4. When it contains chlorophyll, it performs photosynthesis.

Identify the tissue described by the above statements.

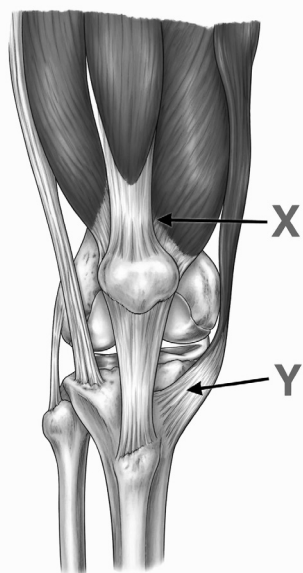
- (A) Collenchyma
- (B) Sclerenchyma
- (C) Parenchyma
- (D) Phloem

Ans : (C)

Parenchyma represents the most fundamental simple permanent tissue in plants. It is composed of unspecialized, living cells with thin walls and noticeable intercellular spaces. Its primary biological role involves storing food nutrients. Furthermore, specialized variations of this tissue can perform vital functions like photosynthesis and providing buoyancy to aquatic plants.

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20. The diagram illustrates a human knee joint. Which of the following accurately describes the primary function of the connective tissues labeled 'X' and 'Y'?



- (A) 'X' limits joint movement to prevent dislocation, while 'Y' transmits force for movement.
- (B) 'X' transmits muscular force to the bone, while 'Y' provides stability and limits excessive movement.
- (C) 'X' cushions the ends of bones to absorb shock, while 'Y' attaches muscles to bones.
- (D) 'X' provides rigid structural support, while 'Y' produces red blood cells for the body.

Ans : (B)

Structure 'X' represents a tough tendon, which firmly connects skeletal muscle to bone and actively transmits the mechanical force required for voluntary movement. Structure 'Y' represents a ligament, which connects adjacent bones to stabilize the joint and prevent dangerous dislocation. Cartilage provides the cushioning shock absorption at the bone ends.

21. Aquatic plants such as the water hyacinth can float efficiently on the water's surface. Which specialized plant tissue is directly responsible for providing this required buoyancy?

- (A) Chlorenchyma
- (B) Aerenchyma
- (C) Sclerenchyma
- (D) Collenchyma

Ans : (B)

In numerous aquatic plant species, specialized parenchyma tissue develops exceptionally large, continuous air cavities within its cellular structure. This heavily modified tissue is specifically termed aerenchyma. The trapped air within these large intercellular spaces provides significant buoyancy, easily allowing aquatic plants to float effectively upon the surface of the water.

22. The leaf stalks of coriander are remarkably flexible and can bend considerably without breaking easily. Which underlying supporting tissue primarily provides this vital mechanical flexibility?

- (A) Xylem fibres
- (B) Sclerenchyma
- (C) Collenchyma
- (D) Apical meristem

Ans : (C)

Collenchyma is a living mechanical tissue that provides essential structural support coupled with high flexibility. Its cells feature specialized uneven thickenings at their corners due to pectin deposition. This unique structural configuration allows various plant parts, such as delicate leaf stalks and young stems, to bend significantly under stress without breaking.

23. **Assertion (A):** The hard outer covering of a coconut husk is exceptionally tough and fibrous.

Reason (R): The husk is composed primarily of dead sclerenchyma tissue that possesses thick, heavily lignified cell walls.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The extreme hardness and resilient fibrous nature of a coconut husk result directly from sclerenchymatous tissue. This particular supporting tissue consists entirely of dead cells completely devoid of protoplasm. Their cell walls are massively thickened by heavy lignin deposits, which provide tremendous mechanical strength and rigidity to the husk structure.

24. Identify the specific plant tissues P, Q, and R based on their observed structural characteristics and corresponding functional roles.

Tissue	Cell Wall Nature	Intercellular Spaces	Observed Function
Tissue P	Thin cellulosic	Large air spaces present	Provides buoyancy in aquatic plants
Tissue Q	Unevenly thickened at corners	Absent	Allows flexible bending without breaking
Tissue R	Thick lignified walls	Absent	Provides extreme hard rigidity to seed coats

- (A) P-Collenchyma, R-Sclerenchyma
 (B) P-Parenchyma, R-Collenchyma
 (C) P-Parenchyma, R-Sclerenchyma
 (D) P-Sclerenchyma, R-Parenchyma

Ans : (C)

Tissue P provides aquatic buoyancy due to its uniquely large intercellular air spaces, identifying it as specialized parenchyma. Tissue Q allows flexible bending through its unevenly thickened cell corners, a key characteristic of collenchyma. Finally, Tissue R imparts extreme structural

rigidity via thick lignified walls without spaces, correctly identifying dead sclerenchyma.

25. Complex permanent tissues in plants are distinct from simple permanent tissues. Which structural feature accurately defines a complex permanent tissue?
 (A) It consists solely of identically shaped cells performing various unrelated functions.
 (B) It is strictly made of dead cells used exclusively for mechanical support.
 (C) It is composed of more than one type of cell working together as a single unit.
 (D) It is found exclusively in the actively dividing tips of stems and roots.

Ans : (C)

Unlike simple permanent tissues containing uniformly identical cells, complex permanent tissues are structurally constructed from multiple different types of cells. Despite their varied individual structures, these diverse cells coordinate their activities seamlessly to function together as a unified system, performing specialized tasks such as transporting water or translocating food.

26. Consider the following cellular elements:
 1. Tracheids
 2. Sieve tubes
 3. Vessels
 4. Xylem parenchyma
 Which combination represents the components exclusively found within the xylem tissue?
 (A) 1, 2, and 3
 (B) 1, 3, and 4
 (C) 2, 3, and 4
 (D) 1, 2, and 4

Ans : (B)

Xylem represents a complex plant vascular tissue primarily functioning in water transport. It is composed of highly specialized cellular elements: tracheids, vessels, xylem parenchyma, and xylem fibres. Sieve tubes, conversely, are dedicated food-conducting elements exclusively associated with the phloem tissue, not the water-conducting xylem network within the plant.

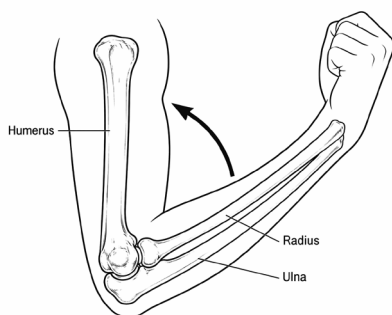
27. Among the various distinct components that construct the xylem tissue, which is the only living component responsible for storing reserve food?
 (A) Tracheids
 (B) Vessels

- (C) Xylem fibres
(D) Xylem parenchyma

Ans : (D)

Within the structural composition of the xylem complex tissue, tracheids, vessels, and xylem fibres are fundamentally dead structures possessing thick lignified walls for mechanical support and water transport. Xylem parenchyma is the only living cellular component within this group, primarily functioning to store essential nutrients and facilitate lateral water conduction.

28. Based on the movement depicted in the schematic diagram of the elbow, which category of joint facilitates this specific unidirectional motion?



- (A) Ball and socket joint
(B) Pivot joint
(C) Hinge joint
(D) Fixed joint

Ans : (C)

The elbow joint permits bending and straightening motions primarily restricted to a single anatomical plane, functioning much like a heavy door swinging on its hinges. This limited, unidirectional movement is highly characteristic of a hinge joint, unlike ball and socket joints which allow broad circular motion, or pivot joints permitting rotation.

29. F.C. Steward demonstrated cellular totipotency using carrot plant cells. Arrange the steps of tissue culture regeneration in the correct developmental sequence.
1. Plantlet is cultured on solid agar medium.
 2. Mature cells dedifferentiate into an unspecialized mass.
 3. Single cells are free in suspension liquid medium.
 4. Undifferentiated cells redifferentiate to form roots and shoots.

5. Small cell fragments are isolated from carrot phloem.
(A) 5, 3, 2, 4, 1
(B) 5, 2, 3, 4, 1
(C) 3, 5, 2, 1, 4
(D) 5, 3, 4, 2, 1

Ans : (A)

The totipotency experiment begins by isolating tiny tissue fragments. These release single cells into suspension. The mature cells then dedifferentiate, reverting to a dividing state. Subsequently, they divide and redifferentiate to form new organized embryonic structures, which finally grow into complete plantlets upon transfer to a solid agar nutrient medium.

30. Phloem is a vital complex permanent tissue involved in internal biological transport. Unlike the xylem, most of the cells composing the phloem tissue are:
(A) Dead, with heavily lignified cell walls
(B) Living, with the exception of phloem fibres
(C) Actively dividing meristematic cells
(D) Devoid of any cellular cytoplasm

Ans : (B)

Phloem operates as the primary food-conducting tissue throughout the plant body. In stark contrast to the predominantly dead cells of the xylem, the structural components of phloem, including sieve tubes, companion cells, and phloem parenchyma, are structurally living cells. Only the phloem fibres are dead, providing necessary mechanical support.

31. Within the complex structure of phloem tissue, the primary cellular functions of the sieve tubes are rigorously monitored and regulated by which adjacent specialized cells?
(A) Phloem fibres
(B) Sieve pores
(C) Phloem parenchyma
(D) Companion cells

Ans : (D)

Sieve tubes represent elongated, tubular conducting cells within the phloem that lack a distinct nucleus at maturity. Consequently, their internal cellular activities and metabolic functions are intimately regulated by adjacent, fully nucleated companion cells. These specialized companion cells closely control the vital loading and unloading processes of transportable sugars.

- 32.** The transportation of biological materials through complex permanent tissues occurs in specific directions. Which statement correctly distinguishes the transport directionality of xylem and phloem?

- (A) Both xylem and phloem transport materials strictly in an upward direction.
- (B) Xylem transports materials bidirectionally, while phloem transports them unidirectionally.
- (C) Xylem transports water upward, while phloem can transport food in multiple directions.
- (D) Phloem transports water downward, while xylem transports food upward.

Ans : (C)

Xylem tissue is strictly responsible for the unidirectional upward conduction of water and dissolved soil minerals from the root system to the upper leaves. Phloem tissue is responsible for translocating synthesized organic food materials from the photosynthetic leaves simultaneously in multiple directions toward both growing shoot apices and storage roots.

- 33.** Evaluate the following statements regarding the structural properties of animal epithelial tissues:

- 1. The cells are tightly packed together forming continuous sheets.
- 2. There is an abundance of intercellular matrix separating the cells.
- 3. It regulates the exchange of materials between the body and the external environment.

Which of the given statements are correct?

- (A) 1 and 2
- (B) 2 and 3
- (C) 1 and 3
- (D) 1, 2, and 3

Ans : (C)

Epithelial tissue serves as the primary protective covering for the animal body. Its cellular structure is characterized by tightly packed, contiguous cells forming an uninterrupted sheet with minimal intercellular space or matrix. This structural arrangement allows it to effectively regulate and monitor the exchange of substances across vital biological boundaries.

- 34.** Rapid diffusion of essential respiratory gases and vital fluids must occur across extremely thin biological membranes. Which specific type of epithelial tissue facilitates this critical physiological process?

- (A) Stratified squamous epithelium

- (B) Simple squamous epithelium
- (C) Cuboidal epithelium
- (D) Columnar epithelium

Ans : (B)

Simple squamous epithelium consists of an exceptionally thin, flattened, and delicate single layer of cells. This highly permeable microscopic structure provides the minimal barrier resistance necessary for the rapid and efficient diffusion of gases and dissolved molecules, particularly within the sensitive linings of pulmonary alveoli and delicate blood capillaries.

- 35.** Which combination correctly matches the structural adaptations of the sampled tissues to their primary biological functions?

Sample	Microscopic Observation	Anatomical Location
Sample 1	Single layer of thin, flat cells	Inner lining of blood vessels
Sample 2	Multiple layers of tightly packed cells	Outer skin surface
Sample 3	Single layer of tall, pillar-like cells	Inner lining of small intestine

- (A) Sample 1: Rapid diffusion; Sample 2: Mechanical protection; Sample 3: Efficient absorption
- (B) Sample 1: Secretion of mucus; Sample 2: Sensory reception; Sample 3: Mechanical protection
- (C) Sample 1: Mechanical protection; Sample 2: Rapid diffusion; Sample 3: Secretion of enzymes
- (D) Sample 1: Efficient absorption; Sample 2: Structural support; Sample 3: Rapid diffusion

Ans : (A)

Sample 1 features a single layer of thin, flat cells that facilitate the rapid diffusion of gases and liquids. Sample 2 contains multiple tightly packed layers specifically designed to protect underlying tissues against mechanical wear. Sample 3 comprises tall, pillar-like cells that maximize the surface area for efficient nutrient absorption.

- 36.** Review the different types of epithelial tissues and their primary biological functions:

- 1. Squamous epithelium helps in rapid diffusion.
- 2. Stratified epithelium protects against mechanical injury and friction.

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3. Cuboidal epithelium forms specialized sensory receptors.
4. Columnar epithelium aids in the efficient absorption of nutrients.

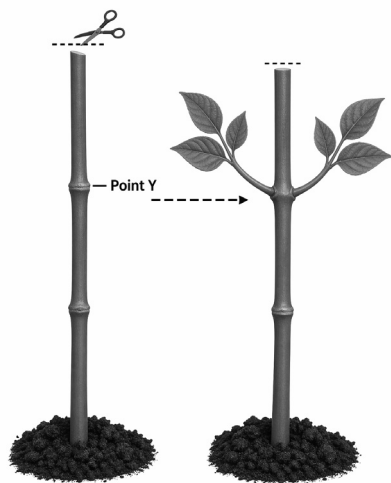
Which combination represents the correct functional descriptions?

- (A) 1, 2, and 4
- (B) 1, 3, and 4
- (C) 2, 3, and 4
- (D) 1, 2, and 3

Ans : (A)

Squamous epithelium facilitates diffusion. Stratified epithelium, possessing multiple thick cellular layers, offers robust protection against friction. Columnar epithelium maximizes nutrient absorption in intestines. However, cuboidal epithelium is primarily dedicated to secretion and mechanical support in ducts, while specialized sensory functions are generally performed by distinct, highly modified sensory cells.

37. A gardener observes that whenever the top portion of a hedge is trimmed, the plant responds by developing a bushy appearance with multiple new lateral branches emerging from specific points along the stem. Identify the specific tissue responsible for this localized growth pattern.



- (A) Apical meristem promoting vertical extension from the cut tip.
- (B) Lateral meristem increasing the radial girth of the remaining stem.
- (C) Intercalary meristem located at the nodes initiating new shoots.
- (D) Simple permanent tissue rapidly dividing to replace lost cells.

Ans : (C)

The diagram illustrates new branches emerging from a node (Point Y) after the apex is removed. This regeneration is driven by the intercalary meristem, located at the base of leaves or internodes. Apical meristems are removed by trimming, lateral meristems increase thickness, and permanent tissues generally lack the ability to divide continuously.

38. The inner lining of the human respiratory tract contains a specialized type of epithelial tissue equipped with hair-like microscopic projections. What is the primary biological function of these cellular structures?

- (A) They rapidly absorb atmospheric oxygen directly into the bloodstream.
- (B) They secrete digestive enzymes to breakdown airborne particles.
- (C) They move rhythmically to clear trapped mucus and foreign particles.
- (D) They act as rigid structural supports to keep the airway open.

Ans : (C)

The respiratory tract is lined internally with ciliated columnar epithelium. The delicate, hair-like cilia on these specialized cells exhibit continuous rhythmic beating motions. This coordinated mechanical movement effectively sweeps secreted mucus, along with any trapped dust and foreign microbial particles, continuously outward to keep the vital respiratory airways clean.

39. **Assertion (A):** Epithelial tissue serves as a highly effective protective barrier against harmful pathogenic microbes.

Reason (R): Epithelial cells are completely devoid of any nuclei, which structurally prevents bacterial multiplication.

- (A) Both A and R are true and R is the correct explanation of A
- (B) Both A and R are true but R is not the correct explanation of A
- (C) A is true but R is false
- (D) A is false but R is true

Ans : (C)

Epithelial tissue definitely acts as an essential physical barrier preventing microbial entry. However, the underlying reason is its densely packed, continuous cellular structure featuring minimal intercellular spaces, not an absence of nuclei. Epithelial cells are fully functional living cells containing distinct nuclei necessary to sustain their vital cellular metabolism.

40. Connective tissues are widely distributed throughout the animal body. What defining structural characteristic is universally common to almost all types of connective tissues?

- (A) The cells lack a nucleus and constantly undergo active division.
- (B) The cells are tightly joined edge-to-edge without any intercellular gaps.
- (C) The tissue strictly lacks any fluid or solid extracellular components.
- (D) The cells are loosely spaced and embedded within an extracellular matrix.

Ans : (D)

The fundamental defining feature of connective tissues is that their living cells are loosely scattered rather than tightly packed. These sparsely distributed cells are suspended within an abundant extracellular matrix, which can naturally be fluid, jelly-like, dense, or rigidly calcified, depending entirely upon the specific biological function of that tissue.

41. Blood is considered a highly specialized form of fluid connective tissue. It consists of a liquid matrix in which various formed elements are suspended. What is this liquid matrix medically termed?

- (A) Lymph
- (B) Serum
- (C) Plasma
- (D) Cytoplasm

Ans : (C)

Blood fundamentally operates as a fluid connective tissue designed for transport. Its complex extracellular liquid matrix is scientifically termed plasma. This pale fluid suspends all the vital formed elements, including red blood cells, white blood cells, and platelets, effectively facilitating their continuous circulation throughout the entire cardiovascular system.

42. When a person sustains a minor skin cut, the bleeding usually stops spontaneously after a brief period. Which specific cellular component of the blood is primarily responsible for this vital clotting mechanism?

- (A) Red Blood Cells
- (B) White Blood Cells
- (C) Platelets
- (D) Plasma proteins

Ans : (C)

Following a vascular injury, specialized microscopic cell fragments circulating in the blood, known as platelets, aggregate rapidly at the exact site of the wound. They immediately trigger a complex biochemical clotting cascade, efficiently forming a stable physical plug that effectively seals the ruptured vessel and prevents potentially fatal blood loss.

43. Based on the clinical observations presented, identify the specific connective tissues that have been severely damaged in Patients X, Y, and Z.

Patient	Injury Description	Compromised Connection
Patient X	Lower leg cannot move when the thigh muscle contracts	Muscle-to-bone connection is entirely torn
Patient Y	Knee joint abnormally bends sideways beyond its normal limit	Bone-to-bone stabilization is structurally broken
Patient Z	Severe pain and friction generated during walking	Smooth covering at bone extremities is worn away

- (A) Patient X: Ligament; Patient Y: Tendon; Patient Z: Cartilage
- (B) Patient X: Tendon; Patient Y: Ligament; Patient Z: Cartilage
- (C) Patient X: Cartilage; Patient Y: Ligament; Patient Z: Tendon
- (D) Patient X: Tendon; Patient Y: Cartilage; Patient Z: Ligament

Ans : (B)

Tendons structurally connect muscles to bones; therefore, their disruption prevents muscle contractions from generating skeletal movement. Ligaments connect bone to bone to stabilize joints, and their injury allows abnormal overextension. Cartilage provides a smooth, shock-absorbing surface at bone extremities, which prevents painful friction during regular physical movements and joint articulations.

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44. Bone provides structural framework and rigid support to the vertebrate body. Evaluate the following biochemical statements regarding the structural composition of the bone matrix:

1. It is primarily composed of flexible protein fibres alone.
2. It contains a high concentration of calcium compounds.
3. It contains significant amounts of phosphorus compounds.
4. It is entirely fluid and devoid of rigid mineral salts.

Which statements accurately describe the composition of bone matrix?

- (A) 1 and 2
(B) 2 and 3
(C) 3 and 4
(D) 1 and 4

Ans : (B)

Bone tissue is biologically engineered to provide maximum mechanical strength and rigid support. Consequently, its dense extracellular matrix is heavily fortified and calcified with substantial inorganic deposits, predominantly consisting of hard calcium and phosphorus mineral compounds, which completely replace the soft, flexible matrix found in other connective tissues.

45. Match the various connective tissues in List-I with their specific physiological functions in List-II.

List-I (Tissue Type)		List-II (Function)	
P.	Bone	1.	Connects skeletal muscle fibers to rigid bones
Q.	Cartilage	2.	Connects two articulating bones together at a joint
R.	Tendon	3.	Provides a hard, non-flexible structural skeletal framework
S.	Ligament	4.	Smoothens joint surfaces and provides flexible support

- (A) P-3, Q-4, R-1, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

Ans : (A)

Bone forms the hard, non-flexible skeletal framework. Cartilage possesses a flexible matrix providing cushioning and smooth surfaces at joints. Tendons are tough, fibrous tissues securely attaching contracting muscles to bones. Ligaments are elastic connective bands precisely designed to connect adjacent bones together, stabilizing joint structures against excessive movement.

46. An athlete sustains a severe injury resulting in the unnatural dislocation of the knee joint. Which vital connective tissue, responsible for holding the articulating bones securely in place, is most likely to have been severely overstretched or torn?

- (A) Tendon
(B) Cartilage
(C) Ligament
(D) Areolar tissue

Ans : (C)

Ligaments are strong, highly elastic connective tissues specifically adapted to connect one bone directly to another bone across a joint structure. Their primary physiological role is maintaining skeletal stability while permitting limited movement. A sudden joint dislocation clearly indicates that the supporting ligaments have suffered significant mechanical failure or tearing.

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47. The human musculoskeletal system requires forces generated by muscle contraction to be efficiently transferred to the skeleton. Which specialized connective tissue strictly performs this critical mechanical transmission?

- (A) Ligament
(B) Tendon
(C) Smooth muscle
(D) Nervous tissue

Ans : (B)

Tendons are incredibly tough, dense, fibrous connective tissues possessing immense tensile strength with very limited elasticity. They serve the critical mechanical function of firmly attaching skeletal muscle tissues to rigid bone structures, reliably transmitting the powerful pulling forces generated during muscular contraction to create deliberate bodily movements.

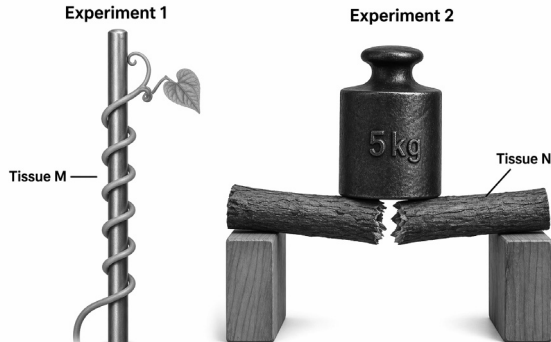
48. Cartilage provides essential flexible structural support and reduces mechanical friction within the human body. Which of the following anatomical locations does NOT naturally contain protective cartilage tissue?

(A) The external pinna of the ear
 (B) The tip of the nose
 (C) The internal lining of the stomach
 (D) Between the articulating ends of long bones

Ans : (C)

Cartilage operates as a firm but highly flexible supportive connective tissue deliberately positioned in areas requiring structural shape without absolute rigidity, such as the outer ear, the nose tip, and the smooth articulating ends of long bones. The stomach lining, however, is strictly composed of specialized secretory epithelial tissue.

49. Two distinct plant structures are subjected to physical stress tests to observe their mechanical properties. Based on the outcomes of these tests, identify the primary simple permanent tissues dominating the structural composition of the tested materials.



- (A) Tissue M is primarily Sclerenchyma; Tissue N is primarily Parenchyma.
 (B) Tissue M is primarily Collenchyma; Tissue N is primarily Sclerenchyma.
 (C) Tissue M is primarily Parenchyma; Tissue N is primarily Collenchyma.
 (D) Tissue M is primarily Sclerenchyma; Tissue N is primarily Apical meristem.

Ans : (B)

The flexible green tendril (Tissue M) bends without breaking, a characteristic mechanical property provided by living collenchyma tissue with pectin-thickened corners. The dry, snapping woody branch (Tissue N) is hard and brittle,

indicating the presence of dead sclerenchyma tissue with thick, lignin-deposited walls. Parenchyma primarily serves for storage, not high tensile strength.

50. Evaluate the following structural and functional characteristics related to a specific type of muscular tissue:

1. The movements produced are entirely under conscious voluntary control.
2. The muscle fibers are long, cylindrical, unbranched, and multinucleate.
3. The cells lack any visible microscopic light and dark striations.

Which combination identifies the true features of skeletal muscles?

- (A) 1 and 2
 (B) 2 and 3
 (C) 1 and 3
 (D) 1, 2, and 3

Ans : (A)

Skeletal muscles precisely control voluntary bodily movements dictated by conscious thought. Microscopically, their specialized cellular fibers appear long, distinctly cylindrical, completely unbranched, and uniquely contain multiple nuclei. Furthermore, they are prominently characterized by highly visible alternating light and dark transverse bands, collectively referred to as microscopic striations.

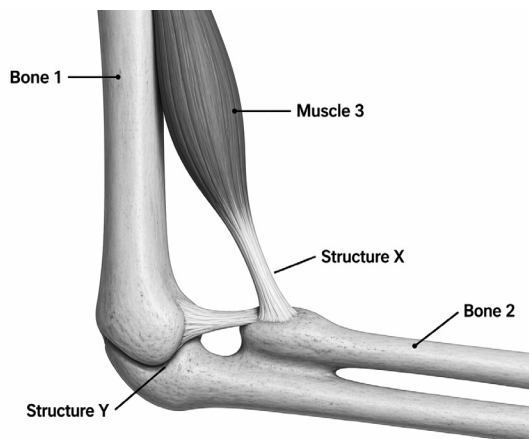
51. Smooth muscles are primarily responsible for executing essential involuntary movements within the body. Which physiological action among the following is completely managed by smooth muscle activity?

- (A) Rapidly lifting a heavy object from the floor
 (B) Moving rhythmic food masses through the digestive intestine
 (C) The continuous, lifelong rhythmic beating of the human heart
 (D) Turning the head deliberately to look sideways

Ans : (B)

Smooth muscles consist of involuntary, spindle-shaped cells dedicated to producing slow, sustained physiological movements beyond conscious control. They line vital hollow internal organs, precisely executing essential automated actions such as the rhythmic peristaltic movement of digested food masses moving continuously through the long tubular structure of the intestinal tract.

52. Movement in the human body requires the coordinated action of the skeletal and muscular systems, structurally linked by specific connective tissues. Based on the anatomical attachments shown in the provided joint model, correctly identify the classification of the highlighted structures.



- (A) Structure X is a ligament connecting muscle to bone; Structure Y is a tendon connecting bone to bone.
 (B) Structure X is a tendon connecting muscle to bone; Structure Y is a ligament connecting bone to bone.
 (C) Both Structure X and Structure Y are specialized epithelial tissues facilitating joint lubrication.
 (D) Structure X is a voluntary muscle fiber bundle; Structure Y is an involuntary cartilage band.

Ans : (B)

Structure X attaches Muscle 3 to Bone 2, acting as a tendon to transmit muscular force necessary for joint movement. Structure Y connects Bone 1 directly to Bone 2, acting as a ligament to stabilize the joint and prevent dislocation. Tendons and ligaments are dense connective tissues, fundamentally distinct from epithelial or muscular tissues.

53. A person accidentally touches a hot surface and immediately withdraws their hand. Select the correct sequential order of the biological structures involved in transmitting this vital sensory and motor message.
1. Dendrites of sensory neuron receive the sudden stimulus.
 2. The brain or spinal cord processes the critical information.
 3. The message travels along the elongated nerve axon.
 4. Motor neurons precisely signal the specific arm muscle to contract.

- (A) 1, 3, 2, 4
 (B) 1, 2, 3, 4
 (C) 3, 1, 2, 4
 (D) 2, 1, 4, 3

Ans : (A)

Initially, the branching dendrites of specialized sensory neurons detect the thermal stimulus. The resulting electrical impulse travels immediately down the cellular axon. This urgent signal reaches the central nervous system for rapid processing. Consequently, a motor command is dispatched to the skeletal muscles, causing the swift withdrawal action.

54. Cardiac muscles possess unique structural and functional properties that distinguish them from both skeletal and smooth muscles. Which of the following accurately describes the microscopic cellular structure of cardiac muscle tissue?
- (A) Spindle-shaped, unbranched, and lacking striations
 (B) Cylindrical, highly branched, possessing striations, and uninucleate
 (C) Long, cylindrical, strictly unbranched, and multinucleate
 (D) Flat, tightly packed layers forming continuous sheets

Ans : (B)

Cardiac muscle tissue is uniquely localized exclusively within the heart wall. Its specialized cells appear microscopically cylindrical and feature complex branched interconnections. Unlike skeletal muscle, each cell generally possesses only a single central nucleus (uninucleate). However, similar to skeletal muscle, they exhibit faint transverse striations across their cellular structure.

55. **Assertion (A):** The specialized cardiac muscles of the heart continuously contract and relax rhythmically throughout an organism's entire life cycle without ever experiencing physical fatigue.
Reason (R): Cardiac muscles operate strictly under conscious voluntary control, allowing the brain to strategically rest them during periods of deep sleep.
- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A

- (C) A is true but R is false
(D) A is false but R is true

Ans : (C)

Cardiac muscles indeed function tirelessly, rhythmically contracting throughout a lifetime without succumbing to muscular fatigue due to their specialized cellular metabolism and abundant blood supply. However, they are fundamentally involuntary muscles, meaning their continuous autonomous rhythmic activity operates completely independent of any conscious or voluntary cognitive control.

56. What biological joint classifications correspond directly to the mechanical joints K, L, and M designed for a structurally accurate anatomical robot?

Robot Joint	Permitted Movement Directions	Human Anatomical Analog
Joint K	Forward, backward, sideways, and circular motions	Human shoulder joint
Joint L	Only bending and straightening strictly within a single plane	Human elbow joint
Joint M	Side-to-side rotation purely around a central axis	Human neck joint

- (A) Joint K: Hinge joint; Joint L: Pivot joint; Joint M: Ball and socket joint
(B) Joint K: Pivot joint; Joint L: Hinge joint; Joint M: Fixed joint
(C) Joint K: Ball and socket joint; Joint L: Hinge joint; Joint M: Pivot joint
(D) Joint K: Ball and socket joint; Joint L: Fixed joint; Joint M: Hinge joint

Ans : (C)

Joint K permits motion in multiple directions, mimicking the wide rotational capacity characteristic of a biological ball and socket joint. Joint L operates strictly in one specific plane, structurally representing a biological hinge joint. Joint M allows localized side-to-side rotational movement around a central axis, identical to a pivot joint.

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57. Neurons constitute the fundamental structural and functional units of the complex nervous system. In a typical specialized neuron cell, which specific structural extension is primarily responsible for transmitting electrical messages away from the main cell body?
- (A) The nucleus
(B) The short, branched dendrites
(C) The long, singular axon
(D) The synaptic gap

Ans : (C)

A specialized neuron cell fundamentally comprises a central cell body, multiple short branching dendrites, and typically one elongated fiber termed the axon. While dendrites are designed to receive incoming chemical and electrical signals, the axon serves the critical function of rapidly transmitting the outgoing electrical impulses away towards target cells.

58. The human skeletal system forms a complex bony framework serving multiple vital biological functions. What is the primary protective role specifically performed by the rib cage?
- (A) To securely protect the delicate spinal cord from physical injury
(B) To primarily produce essential red and white blood cells
(C) To safely enclose and protect vital internal organs like the heart and lungs
(D) To provide the main structural attachment points for powerful leg muscles

Ans : (C)

The human rib cage consists of 12 pairs of curved bony ribs forming a resilient, partially flexible protective enclosure. Its most critical anatomical function is to safely shield extremely delicate and vital internal organs, specifically the beating heart and the expanding respiratory lungs, from severe external mechanical trauma.

59. Evaluate the different types of skeletal joints and their functional movement characteristics:
1. The hinge joint strictly allows physical movement in only one plane.
 2. The ball and socket joint permits multidirectional circular movements.
 3. The pivot joint enables the head to smoothly rotate from side to side.
 4. Fixed joints securely connect skull bones, preventing any internal brain movement.

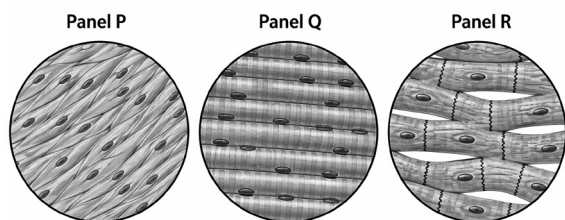
Which of the given statements are correct?

- (A) 1, 2, and 3
- (B) 2, 3, and 4
- (C) 1, 3, and 4
- (D) 1, 2, 3, and 4

Ans : (D)

Each skeletal joint structure precisely dictates its specific functional movement. Hinge joints function like simple door hinges (one direction). Ball and socket joints offer extensive rotational freedom. The pivotal neck joint facilitates necessary lateral head rotation. Fixed cranial joints remain entirely immovable, rigidly locking the protective skull bones together.

60. Microscopic examination of muscular tissues reveals varying cellular architectures that directly correlate with their specific physiological functions in the body. Analyze the microscopic fields provided and identify the correct functional pairing.



- (A) Panel P controls continuous heartbeat; Panel Q controls intestinal movement.
- (B) Panel Q facilitates voluntary weight lifting; Panel R ensures continuous blood pumping.
- (C) Panel R causes the digestion of food; Panel P supports voluntary walking.
- (D) Panel P enables conscious writing; Panel Q handles involuntary pupil dilation.

Ans : (B)

Panel Q displays skeletal muscle (cylindrical, unbranched, multinucleate, striated), responsible for conscious, voluntary movements like weight lifting. Panel R displays cardiac muscle (branched, uninucleate, striated), found exclusively in the heart for continuous, fatigue-free pumping. Panel P displays smooth muscle (spindle-shaped, unstriated), which controls involuntary internal organ movements like those in the digestive tract.

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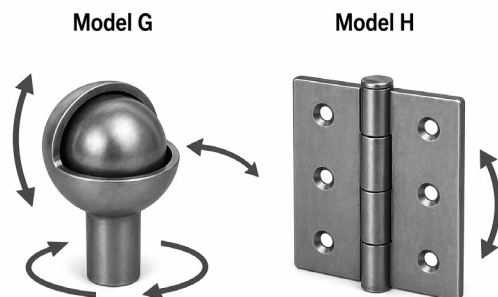
61. An athlete successfully performs a series of full circular arm rotations during a thorough physical warm-up routine. Which specific joint anatomical structure facilitates this extensive range of rotational movement at the shoulder?

- (A) Fixed joint
- (B) Pivot joint
- (C) Ball and socket joint
- (D) Hinge joint

Ans : (C)

The human shoulder anatomy features a highly mobile ball and socket joint. In this specific configuration, the rounded spherical head of the upper arm bone sits smoothly into a shallow corresponding cavity of the shoulder blade, uniquely permitting extensive forward, backward, lateral, and complete circular rotational movements.

62. The human skeletal system utilizes different mechanical joint designs to allow varying degrees of freedom and planes of movement. Match the mechanical equivalents shown below to their corresponding anatomical locations.



- (A) Model G represents the neck articulation; Model H represents the shoulder joint.
- (B) Model G represents the knee joint; Model H represents the cranial bones of the skull.
- (C) Model G represents the shoulder joint; Model H represents the elbow joint.
- (D) Model G represents the elbow joint; Model H represents the hip joint.

Ans : (C)

Model G depicts a ball-and-socket mechanism, which allows multi-directional and circular movement; this structurally corresponds to the shoulder and hip joints. Model H depicts a hinge mechanism, which strictly limits movement to a single plane (bending and straightening); this directly corresponds to the elbow and knee joints.

63. The complex human skull safely encloses the delicate brain mass. It is anatomically connected to the flexible vertebral column (backbone) via a specific type of joint that distinctly allows you to physically shake your head 'no'. Which type of joint is this?
- (A) A rigidly immovable fixed joint
 (B) A highly flexible pivot joint
 (C) A restricted unidirectional hinge joint
 (D) A freely rotating ball and socket joint

Ans : (B)

The precise anatomical connection existing between the base of the skull and the uppermost vertebrae of the spinal column functions as a specialized pivot joint. This specific mechanical configuration uniquely permits the structural rotation required to smoothly turn the head laterally from side to side upon the vertical spinal axis.

64. **Assertion (A):** The interconnected flat bones forming the adult human skull are incapable of movement relative to one another.
Reason (R): These specific cranial bones are securely fused together by fixed joints, providing a rigid, completely enclosed protective vault for the delicate internal brain tissue.
- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The primary structural imperative of the human cranium is the absolute physical protection of highly sensitive brain tissue. To achieve this rigid stability, the individual flat bones comprising the adult skull are permanently locked together by immovable fixed joints, eliminating any potential movement that could compromise or compress brain structure.

65. The human backbone is not formed from a single rigid bone but is constructed from numerous small, individual vertebrae. What specialized connective tissue exists precisely between these vertebrae to act as a shock-absorbing cushion and facilitate essential spinal flexibility?
- (A) Strong, non-elastic tendons
 (B) Solid, rigid bone matrix
 (C) Soft, flexible cartilage discs
 (D) Liquid blood plasma

Ans : (C)

The vertebral column must maintain vertical structural support while simultaneously permitting necessary physical flexibility for bending. This is mechanically achieved by situating specialized discs of firm yet slightly compressible cartilage directly between consecutive rigid bony vertebrae, effectively functioning as necessary internal shock absorbers protecting the delicate spinal cord.

VERY SHORT ANSWER

66. Define a tissue in the context of multicellular organisms.

Ans :

A tissue is a group of structurally similar cells that work together to perform a specific function, leading to the division of labour.

67. Why do plant cells need a rigid cell wall unlike animal cells?

Ans :

Plants are fixed in one place and cannot move. The rigid cell wall provides necessary structural strength and upright support to withstand environmental stress.

68. State one difference between plant and animal growth patterns.

Ans :

Plant growth is restricted to specific localized regions containing dividing tissues, whereas animal growth is more uniform across the body without such distinct dividing regions.

69. Where is the apical meristem located in plants?

Ans :

The apical meristem is primarily located at the growing tips of roots and shoots, helping the plant increase in length during its developmental stages.

70. What is the function of the lateral meristem in plants?

Ans :

The lateral meristem consists of actively dividing cells arranged in a ring that continuously divide to increase the overall girth or diameter of the stem.

71. What causes the hedge around a garden to become bushy after it is cut?

Ans :

Cutting the hedge removes apical meristems, stimulating the intercalary meristems located at the nodes to rapidly divide, which promotes new branching and bushy appearance.

72. What is differentiation in the context of plant tissues?

Ans :

Differentiation is the biological process through which cells produced by meristematic tissue lose their dividing ability and take up a permanent shape, size, and function.

73. Give one characteristic property of meristematic tissue cells.

Ans :

Cells of meristematic tissue are highly active, featuring thin cell walls, dense cytoplasm, a large prominent nucleus, and generally lack vacuoles to facilitate continuous division.

74. What role do stomata play in the epidermis of a leaf?

Ans :

Stomata primarily facilitate the exchange of gases for photosynthesis and enable transpiration, which evaporates excess water and creates a pull for transporting water upwards.

75. Why do aquatic plants have specialized parenchyma cells?

Ans :

Aquatic plants possess specialized parenchyma cells containing large air spaces, which provide essential buoyancy to help them easily float on the surface of the water.

76. How is collenchyma structurally different from sclerenchyma?

Ans :

Collenchyma consists of living cells with unevenly thickened corners due to pectin, while sclerenchyma comprises dead cells with uniformly thick walls due to lignin deposition.

77. What is phloem tissue composed of?

Ans :

Phloem is a complex tissue mainly composed of living cells, specifically including sieve tubes, companion cells, phloem parenchyma, and dead supporting cells called phloem fibres.

78. What is the primary function of epithelial tissue in animals?

Ans :

Epithelial tissue provides a protective outer covering for the body and internally lines various organs, significantly reducing water loss and preventing the entry of germs.

79. What would you observe regarding epithelial structure in the small intestine?

Ans :

You would observe a single layer of tall columnar epithelial cells, which are structurally adapted to provide efficient uptake and absorption of essential dietary nutrients.

80. State one difference between the matrix of bone and blood.

Ans :

The matrix of bone is exceptionally hard, solid, and rigid due to calcium compounds, whereas blood possesses a fluid, watery, and soft matrix called plasma.

81. What is the functional significance of platelets in human blood?

Ans :

Platelets play a highly crucial role in the body by initiating blood clotting at injury sites, thereby effectively preventing excessive and dangerous loss of blood.

82. What is the relationship between tendons and skeletal muscles?

Ans :

Tendons are strong, flexible, tough bands of connective tissue that firmly attach skeletal muscles to bones, efficiently transmitting muscular contractile forces to produce joint movement.

83. Give one structural characteristic of cardiac muscle fibers.

Ans :

Cardiac muscle fibers are distinctly cylindrical, highly branched, and structurally have faint striations along with a single central nucleus to support continuous, lifelong rhythmic contractions.

84. What is the axon in a nervous tissue cell?

Ans :

An axon is a specialized, long, thin elongated fiber extending from the neuron's cell body that actively carries and transmits electrical messages toward other cells.

85. What enables the human shoulder to perform forward, backward, sideways, and circular movements?

Ans :

The shoulder features a versatile ball and socket joint, where the rounded upper arm bone perfectly fits into the hollow cavity of the shoulder bone.

86. Where is a pivot joint located in the human body?

Ans :

A pivot joint is structurally located at the back of the neck, seamlessly connecting the rigid skull to the top of the flexible backbone column.

87. What is the role of the human rib cage?

Ans :

The rib cage acts as a sturdy protective enclosure that safely shields delicate vital internal organs like the human heart and lungs from mechanical injuries.

88. What would happen if there were no fixed joints in the human skull?

Ans :

Without fixed joints, skull bones would inevitably shift during movement, failing to provide the essential rigid protection required to keep the delicate brain constantly safe.

89. Under what condition do cells exhibit totipotency according to F. C. Steward's experiment?

Ans :

Plant cells exhibit totipotency when they are properly cultured in an appropriate artificial nutrient medium supplemented with essential specific growth chemicals, vitamins, and appropriate hormones.

90. What is the scientific term for the ability of a single mature plant cell to develop into a complete new plant?

Ans :

The scientific term for this remarkable developmental ability of a single individual mature plant cell to regenerate into a completely entire organism is called totipotency.

91. Who demonstrated the concept of totipotency using carrot phloem cells and when?

Ans :

The ground breaking concept of totipotency was successfully demonstrated by the prominent scientist F. C. Steward in the year 1958 using artificially cultured carrot phloem cells.

92. What is the result of crown gall disease in plants?

Ans :

Crown gall disease essentially results in rapid, heavily uncontrolled cell division, which gradually produces prominent abnormal tumour swellings directly on the stems of affected plants.

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93. Give one use of the bacterium causing crown gall disease in modern science.

Ans :

Agrobacterium is widely utilized today as a powerful biological tool in genetic engineering to introduce highly useful and beneficial genes directly into various target plants.

94. Name the supportive connective tissue that cushions bone ends at joints.

Ans :

Cartilage is the specialised soft, highly flexible connective tissue that effectively cushions bone ends at joints, thereby absorbing sudden mechanical shocks and preventing painful friction.

95. Correct this statement: Smooth muscles are voluntary and help in lifting objects.

Ans :

Skeletal muscles are strictly voluntary and actively help in physically lifting objects, whereas smooth muscles are entirely involuntary and control internal movements like human digestion.

SHORT ANSWER QUESTIONS

96. Explain why plants and animals have fundamentally different types of tissues based on their mobility and lifestyle.

Ans :

Plants are stationary and require extensive supportive tissues for structural rigidity. Consequently, many plant tissues consist of dead cells that provide mechanical strength with low maintenance. In contrast, animals move actively in search of food, mates, and shelter, requiring significantly more energy. Therefore, animal tissues are predominantly composed of living cells that support locomotion, rapid sensory responses, and higher metabolic rates. Additionally, plant growth is localized to specific regions, whereas animal growth is uniform across the entire body.

97. Explain the concept of division of labour in multicellular organisms with the help of tissue formation.

Ans :

In multicellular organisms, a single cell cannot efficiently perform all life processes. Therefore, cells group together to form tissues, where each tissue is specialised to carry out a specific function. For example, in animals, muscle tissue is dedicated to movement, while nervous tissue handles communication. This specialisation means that different tasks are distributed among various groups of cells. This division of labour significantly increases the overall efficiency of the body, allowing complex organisms to survive and coordinate intricate life processes smoothly.

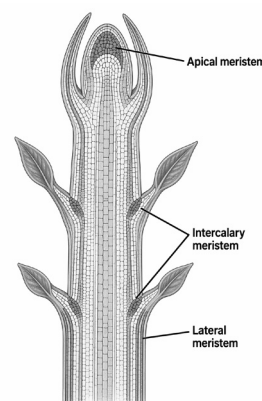
98. A student claims that plants possess more dead tissues compared to animals. Do you agree? Justify your answer based on structural requirements.

Ans :

Yes, I completely agree with this claim. Plants are anchored to one place and do not exhibit locomotion. Their primary survival requirement is mechanical strength to stand upright against environmental forces like wind and gravity. Dead tissues, such as sclerenchyma and xylem vessels, provide excellent rigidity and structural support without the need for cellular maintenance or energy consumption. Animals, however, need flexible, energy-consuming living tissues for movement and complex organ functions, so they have very few dead tissues compared to plants.

99. Draw a labelled diagram showing the location of different meristematic tissues in a plant body. Briefly explain the function of the apical meristem.

Ans :



The apical meristem is located at the growing tips of roots and shoots. Its primary function is to undergo continuous and rapid cell division, which results in an increase in the length of the plant. This primary growth helps roots penetrate deeper into the soil for better water absorption and helps the plant shoots grow taller to access more sunlight necessary for photosynthesis.

100. What are the distinct modes of nutrition in plants and animals? How does this difference affect their specific tissue requirements?

Ans :

Plants are autotrophic and synthesise their own food using solar energy through photosynthesis. They require specialised tissues containing chloroplasts, such as specific parenchyma cells, and complex tissues like xylem to transport raw materials like water from the soil. Animals are heterotrophic and must ingest complex organic

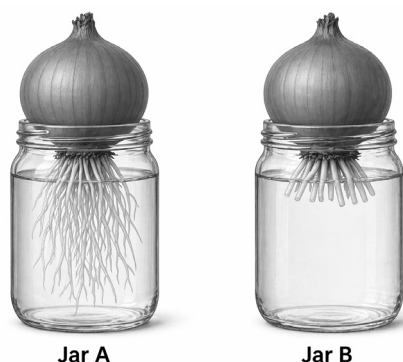
food. Consequently, animals require distinct digestive tissues to break down and absorb nutrients, alongside highly developed muscular and nervous tissues to help them actively move and hunt or forage for this food in their environment.

- 101.** Why do the cells of meristematic tissues generally lack vacuoles? What is the process of differentiation in plant tissues?

Ans :

Meristematic cells are highly active and continuously dividing to facilitate plant growth. They possess dense cytoplasm and thin cell walls but lack vacuoles because vacuoles primarily store sap and provide rigidity, which would hinder rapid cell division. Once these newly formed cells lose their ability to divide, they undergo structural and functional changes to become specialised for specific roles, such as protection or transport. This process of taking up a permanent shape, size, and function is known as cellular differentiation.

- 102.** Study the experimental setup described below.



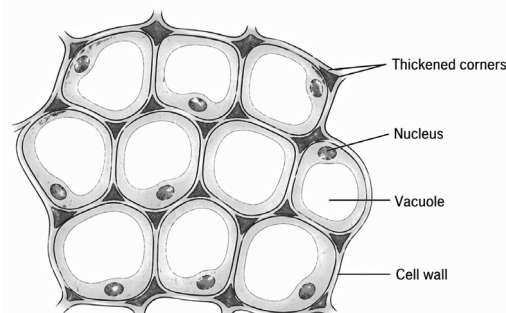
What happens to the growth of roots in Jar B after their tips are cut? Which specific tissue is responsible for this observation?

Ans :

After the root tips in Jar B are cut, the roots will stop growing in length entirely, whereas the intact roots in Jar A will continue to elongate. This cessation of growth occurs because the actively dividing cells responsible for increasing root length are located exclusively at the extreme tips. These specialized dividing regions contain the apical meristem tissue. Removing the tips eliminates the apical meristem, thereby permanently halting any further longitudinal growth of those specific roots.

- 103.** Draw a labelled diagram showing the transverse section of collenchyma tissue. Why are the corners of collenchyma cells thickened?

Ans :



The corners of collenchyma cells are unevenly thickened due to the localized deposition of pectin, a complex carbohydrate. This specific pattern of thickening provides the tissue with a unique combination of tensile strength and flexibility. It allows various plant parts, such as young stems and tendrils, to bend freely under physical stress like strong winds without breaking, while still maintaining structural support.

- 104.** Explain the structural and functional differences between parenchyma and sclerenchyma tissues in plants.

Ans :

Parenchyma consists of loosely packed, living cells with thin cell walls and intercellular spaces. Its primary function is to store food and, in some cases, perform photosynthesis or provide buoyancy. In contrast, sclerenchyma consists of tightly packed, mostly dead cells with extremely thick walls due to the heavy deposition of lignin. Sclerenchyma lacks intercellular spaces and does not store food. Its primary function is to provide vital mechanical strength, rigidity, and protection to plant parts like stems and seed coverings.

- 105.** Why does a fresh twig of a plant bend easily in the wind without breaking, whereas a dry twig snaps easily?

Ans :

A fresh plant twig bends easily without breaking due to the presence of collenchyma tissue. Collenchyma consists of living cells that have unevenly thickened corners caused by the deposition of pectin. This chemical acts somewhat like rubber, providing excellent mechanical

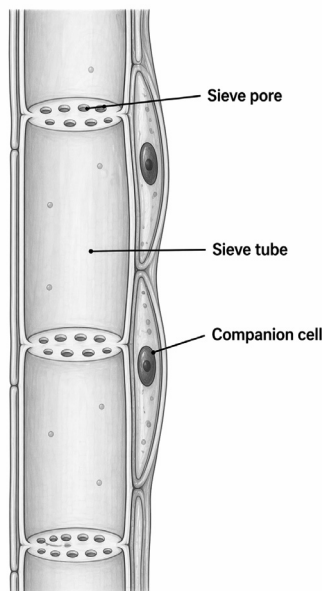
support combined with high flexibility to young stems and leaf stalks. In a dry twig, these living cells die, lose their moisture and pectin flexibility, and the supportive tissues become rigid and brittle, causing the twig to snap under pressure.

- 106.** What is aerenchyma? How does this specialized tissue help aquatic plants survive in their environment?

Ans :

Aerenchyma is a highly specialised form of parenchyma tissue found primarily in aquatic plants. In this tissue, the cells are arranged to form very large, interconnected air cavities or spaces within the plant body. These extensive air spaces trap gases, which makes the plant lightweight and provides significant buoyancy. This buoyancy is crucial for aquatic plants, such as water lilies or lotus, as it allows their stems and leaves to float on the water surface to efficiently capture sunlight for photosynthesis.

- 107.** Study the diagram of the plant tissue provided below.



Identify the complex tissue shown. What is the specific function of the companion cells here?

Ans :

The complex permanent tissue illustrated in the diagram is the phloem. Within this tissue, the companion cells play a critical regulatory role. Mature sieve tube elements lack a prominent nucleus and depend entirely on the adjacent companion cells for their survival and function.

The companion cells actively control the metabolic activities of the sieve tubes and meticulously monitor the loading and unloading of sugars into the sieve tubes for efficient transport throughout the plant body.

- 108.** The outermost layer of a plant body is the epidermis. Describe its primary protective functions and the specific role of the cuticle.

Ans :

The epidermis forms a tightly packed, single continuous layer of cells that covers the entire plant, protecting internal tissues against mechanical injury, harmful microorganism invasion, and excessive water loss. To enhance this protection, the epidermal cells secrete a waxy, water-resistant layer called the cuticle on their outer surface. In dry or desert habitats, this cuticle is exceptionally thick, which is vital for survival as it drastically reduces the rate of water loss through transpiration, preventing the plant from drying out.

- 109.** Explain the composition and function of phloem tissue in plants. How does its cellular nature differ from xylem?

Ans :

Phloem is a complex permanent tissue responsible for transporting prepared food (sugars) from the leaves to all other parts of the plant. It is composed of four elements: sieve tubes, companion cells, phloem parenchyma, and phloem fibres. Unlike xylem, which is predominantly made up of dead cells with heavily lignified walls for water transport, phloem is mostly composed of living cells. Only the phloem fibres are dead sclerenchymatous cells. The living sieve tubes actively manage the bidirectional flow of nutrients.

What is epithelial tissue? Describe the structure and function of the epithelium found specifically in the lining of the small intestine.

Ans :

Epithelial tissue forms the continuous outer covering of the animal body and lines internal organs and cavities, acting as a protective barrier. In the lining of the small intestine, the epithelial tissue is of the columnar type. It consists of a single layer of tall, pillar-like cells, often bearing microscopic hair-like projections called microvilli. This tall cellular structure provides a large

surface area, making it highly efficient for the vital function of absorbing nutrients and water from digested food.

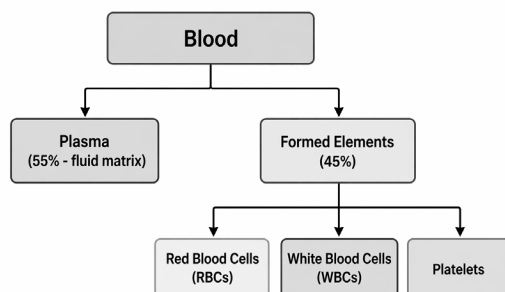
111. Why is the epithelial tissue in the human skin composed of multiple tightly packed layers, while the lining of blood vessels is a single thin layer?

Ans :

The skin is constantly exposed to the external environment, facing continuous friction, mechanical stress, and potential entry of pathogens. Therefore, its epithelium consists of multiple stratified layers to prevent wear and tear and provide robust protection. In contrast, the inner lining of blood vessels functions primarily to allow the rapid diffusion and exchange of gases, nutrients, and waste products between the blood and surrounding tissues. A single, exceptionally thin layer of flat cells ensures this exchange occurs quickly and efficiently.

112. Draw a labelled diagram or flowchart showing the main components of human blood. Why is blood scientifically classified as a connective tissue?

Ans :



Blood is classified as a connective tissue because, like other connective tissues, it consists of living cells suspended in an extensive extracellular matrix. In blood, the RBCs, WBCs, and platelets are loosely embedded in a fluid, watery matrix called plasma. Furthermore, blood fulfils the primary role of a connective tissue by physically connecting different organ systems together, continuously transporting oxygen, nutrients, hormones, and waste products throughout the entire body.

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113. Compare tendons and ligaments with respect to the specific anatomical structures they connect and their physical flexibility.

Ans :

Tendons and ligaments are both dense connective tissues but serve different roles. Tendons connect skeletal muscles to bones. They are incredibly tough, strong, and inelastic cords designed to withstand huge pulling forces transferred from contracting muscles to move the skeleton. Ligaments, on the other hand, connect bone to bone at the joints. While strong, ligaments are highly elastic and flexible, allowing the bones at a joint to move smoothly within a limited range while preventing dislocation.

114. Describe the structural differences between the extracellular matrix of bone and cartilage. How do these differences directly affect their physical properties?

Ans :

The matrix of a bone is highly calcified, rich in calcium and phosphorus compounds, making it hard, solid, and entirely rigid. This provides strong structural support and protection but no flexibility. In contrast, the matrix of cartilage is composed of proteins and sugars, which makes it firm but relatively soft, solid, and jelly-like. This unique composition gives cartilage substantial flexibility and cushioning properties, allowing it to bend slightly and absorb shocks at the ends of long bones and in joints.

115. Suppose a person's blood completely lacked platelets. What would be the immediate consequence if they sustained a minor cut on their skin, and why?

Ans :

If a person completely lacked platelets, a minor skin cut would result in continuous, uncontrolled bleeding. Platelets are specialised cellular fragments circulating in the plasma whose sole critical function is to initiate the blood clotting mechanism at the site of any vascular injury. They clump together and form a plug to seal damaged blood vessels. Without them, the blood would be unable to coagulate and form a protective clot, leading to severe and potentially life-threatening blood loss from even minor wounds.

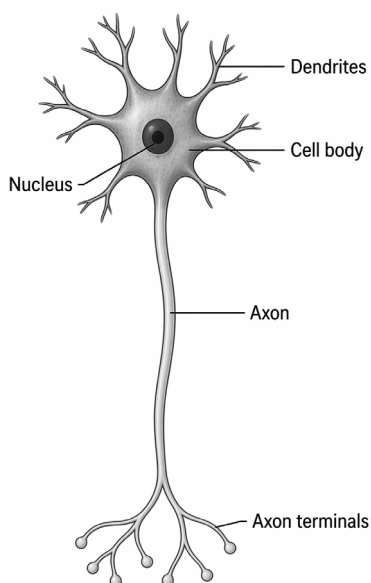
- 116.** Renu says that the movement of food through our intestines is controlled by skeletal muscles because we eat voluntarily. Do you agree? Justify your answer.

Ans :

I completely disagree with Renu's statement. While the initial act of chewing and swallowing food in the mouth is voluntary and controlled by skeletal muscles, the subsequent movement of food through the digestive tract is entirely involuntary. This continuous, rhythmic movement, known as peristalsis, is controlled by smooth muscles lining the intestines. Smooth muscles operate automatically without our conscious thought or control, ensuring digestion proceeds continuously even when we are asleep or not thinking about it.

- 117.** Draw a neat, labelled diagram of a neuron. Briefly state the specific roles of the axon and dendrites in transmitting nervous signals.

Ans :



In a neuron, the dendrites act as the receiving antennas; they pick up incoming electrical or chemical signals from sensory receptors or neighbouring neurons and carry them towards the cell body. The axon acts as the transmitting cable; it carries these processed nerve impulses away from the cell body over long distances to the axon terminals, which then pass the message onto the next neuron, muscle, or gland.

- 118.** Compare skeletal muscles and cardiac muscles specifically with respect to their cell structure and whether their control is voluntary or involuntary.

Ans :

Skeletal muscle cells are long, cylindrical, unbranched, and multinucleate, featuring distinct light and dark bands called striations. Their movement is voluntary, meaning they operate under our conscious control for actions like walking. In contrast, cardiac muscle cells, found only in the heart, are cylindrical but uniquely branched, and typically possess only a single central nucleus per cell. They have faint striations and their function is completely involuntary, contracting rhythmically and tirelessly without any conscious effort throughout a person's lifetime.

- 119.** Cardiac muscles are unique among muscular tissues. Describe their specific structural features and explain their vital, continuous function in the human body.

Ans :

Cardiac muscles are exclusively located in the walls of the human heart. Structurally, their fibres are cylindrical, distinctively branched, and possess a single nucleus. They exhibit faint, lighter striations compared to skeletal muscles. Their most vital characteristic is their ability to work continuously and rhythmically without ever experiencing fatigue. Operating involuntarily, they pump blood tirelessly day and night throughout a person's entire life, ensuring a constant supply of oxygen and nutrients to all body tissues.

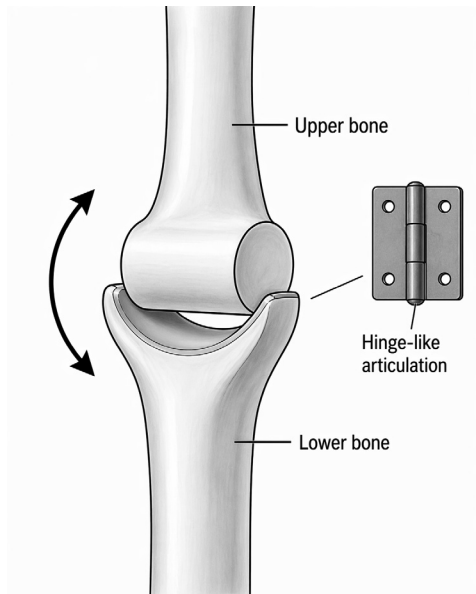
- 120.** What constitutes the musculoskeletal system? Explain how muscles and bones coordinate to successfully produce movement at a joint.

Ans :

The musculoskeletal system comprises the entire framework of bones, skeletal muscles, joints, cartilage, tendons, and ligaments. Movement occurs through the coordinated effort of these components under nervous system control. Muscles, which are attached to bones via strong tendons, operate by contracting. When a muscle receives a nerve signal, it contracts and shortens, forcefully pulling on the tendon. The tendon transmits this mechanical pulling force directly to the bone, causing the skeleton to move smoothly at the articulating joint.

- 121.** Draw a simple diagram illustrating a hinge joint in the human body. How does the movement allowed by a hinge joint differ from that of a ball and socket joint?

Ans :



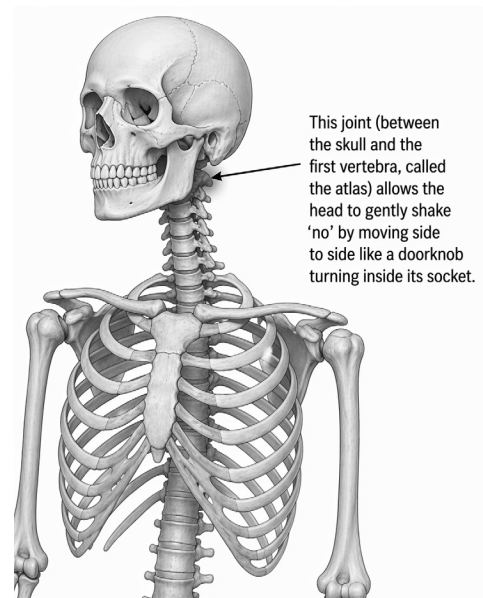
A hinge joint, like the elbow or knee, restricts movement to only one direction or a single plane, functioning exactly like a door opening and closing. In stark contrast, a ball and socket joint, such as the shoulder or hip, features a round bone end fitting into a cup-like cavity. This unique structure allows highly versatile, free movement in multiple directions, including forwards, backwards, sideways, and complete circular rotations.

- 122.** Explain the structure and vital function of the rib cage in the human skeletal system. Why is the presence of flexible cartilage essential in the rib cage?

Ans :

The rib cage consists of 12 pairs of curved bones that connect to the vertebral column at the back and the sternum (breastbone) in the front, forming a protective bony enclosure. Its primary function is to safeguard delicate vital organs, namely the heart and lungs. The ribs are attached to the sternum using flexible cartilage rather than solid bone. This crucial flexibility allows the rib cage to expand outward and contract inward smoothly, altering chest cavity volume to facilitate breathing.

- 123.** Study the description of the skeletal joint below.



Identify the type of joint highlighted between the skull and the backbone. Describe how this joint's movement differs from the fixed joints found within the skull itself.

Ans :

The joint highlighted between the base of the skull and the top of the backbone is a pivot joint. This specialized joint allows for rotational movement, enabling the head to pivot smoothly from side to side, much like turning a doorknob. This is vastly different from the fixed joints that connect the flat bones of the skull. Fixed joints are completely immobile, tightly interlocking the bones to provide rigid, unwavering protection for the delicate brain, allowing absolutely zero movement.

- 124.** Describe the chronological sequence of steps in F.C. Steward's pioneering experiment that successfully demonstrated the totipotency of plant cells.

Ans :

F.C. Steward began by extracting small tissue fragments containing phloem cells from a mature carrot root. He separated these fragments into single, free-floating cells. These individual cells were then cultured in a specialised liquid nutrient medium containing simple sugars and growth hormones, while being constantly stirred. In this environment, the mature cells dedifferentiated, dividing rapidly to form an undifferentiated

mass. Finally, under appropriate conditions, this cellular mass redifferentiated, developing roots and shoots until it formed a complete, fully grown adult carrot plant.

125. Based on F.C. Steward's tissue culture experiment, why was it necessary to add simple sugars and hormones to the nutrient medium? What revolutionary biological concept did the final result prove?

Ans :

Simple sugars were added to the culture medium to act as a vital energy source, replacing the food the cell would normally receive from photosynthesis or plant storage. Growth hormones were essential to artificially stimulate the isolated mature cells to break their resting state and begin dividing repeatedly. The final successful growth of a whole carrot plant from a single phloem cell proved the revolutionary concept of totipotency—the inherent ability of a single mature living cell to regenerate an entire organism.

LONG ANSWER QUESTIONS

126. (a) Why do plants and animals have fundamentally different types of tissues?
 (b) How do you describe the three types of meristematic tissues found in plants based on their specific locations?
 (c) What would eventually happen if the apical meristem of a potted plant is accidentally cut off?

Ans :

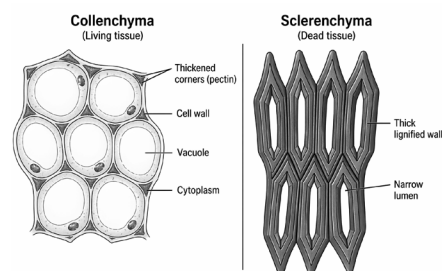
- (a) Plants are mostly stationary and require tissues that provide structural support, hence many of their tissues are dead and rigid. Animals move around to find food, mates, and shelter, so most of their tissues contain living cells that consume more energy.
 (b) Plant growth is restricted to specific regions containing meristematic tissues. The apical meristem is located at the growing tips of roots and shoots, responsible for increasing the length of the plant. The lateral meristem is present along the sides of the stem and roots, increasing their overall girth. The intercalary meristem is found at the base of leaves or internodes, aiding in the growth of branches or regeneration after cutting.

- (c) If the apical meristem of a potted plant is cut off, the plant will immediately stop growing in length from that specific shoot tip. However, it may develop side branches due to intercalary meristems.

127. (a) Can you draw the transverse section showing the cellular structure of collenchyma and sclerenchyma tissues?
 (b) How do you differentiate between these two simple permanent tissues on the basis of their cell wall composition, living nature, and exact function in plants?

Ans :

- (a)



- (b) Collenchyma and sclerenchyma are both simple permanent tissues that provide mechanical support to the plant, but they possess distinct structural differences. Collenchyma consists of living cells with somewhat thin walls that are unevenly thickened at the corners due to pectin deposition. It provides both structural support and vital flexibility, allowing plant parts like stems and leaf stalks to bend easily without breaking during heavy winds. In stark contrast, sclerenchyma consists entirely of dead cells with uniformly thick walls heavily deposited with lignin. This heavily lignified structure makes the tissue exceptionally hard and rigid. Consequently, sclerenchyma primarily imparts immense strength and stiffness to the plant, forming the hard coverings of seeds, nuts, and the robust vascular bundles found within the stems and veins of leaves.

128. (a) What is the primary role of the epidermis in the plant body?
 (b) Can you explain in detail how the basic structure of the epidermis is naturally modified in desert plants and underground roots to perfectly suit their specific environmental functions?

Ans :

- (a) The epidermis is a single-layered outermost tissue that covers the entire plant body, primarily serving to protect underlying tissues from mechanical injury, extreme environmental conditions, and invasion by harmful parasitic microorganisms. It plays a vital role in regulating water loss and gaseous exchange through tiny pores called stomata.
- (b) To survive extreme conditions, the epidermis is structurally modified depending on the plant's habitat. In desert plants, the epidermis is covered by a remarkably thick, waxy coating of cutin. This waterproof layer is crucial for survival as it heavily restricts the loss of water through transpiration in hot, dry climates. Conversely, the epidermal cells of plant roots bear long, hair-like projections called root hairs. These fine tubular extensions greatly increase the total surface area available to the root system, thereby facilitating the maximum possible absorption of water and dissolved minerals from the surrounding soil.

129. (a) How do you define epithelial tissue and state its broad functions in the human body?
- (b) How does the structure of simple squamous epithelium differ from columnar epithelium?
- (c) Why is the outer human skin composed of stratified squamous epithelium instead of a single thin layer of cells?

Ans :

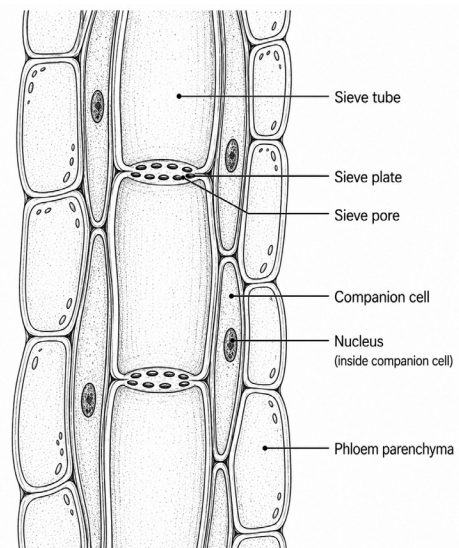
- (a) Epithelial tissue forms the continuous outer covering of the animal body and meticulously lines most internal organs, cavities, and blood vessels. Its primary function is to provide a protective barrier against germs and physical damage while also regulating the exchange of substances, secretion, and absorption.
- (b) The structure of these tissues perfectly matches their function. Simple squamous epithelium consists of a single layer of extremely thin, flat cells that form a delicate lining. This ultra-thin structure allows for the rapid diffusion of gases and liquids, making it ideal for alveoli and blood vessels. In contrast, columnar epithelium features tall, pillar-like cells specifically designed for efficient absorption and secretion, commonly found lining the intestines.

- (c) The skin requires much greater protection against constant friction and wear. Therefore, it is composed of stratified squamous epithelium, where flat cells are arranged in numerous tightly packed layers to prevent continuous mechanical damage.

130. (a) Can you draw a well-labelled diagram showing the longitudinal section of phloem tissue?
- (b) How does the overall function of xylem differ from that of phloem?
- (c) Why are companion cells considered essential for the normal functioning of sieve tubes?

Ans :

- (a)



- (b) Xylem and phloem are complex permanent tissues with entirely different functions. Xylem primarily transports water and dissolved minerals upwards from the roots to the leaves and provides strong mechanical support to the plant structure. It is mainly composed of dead cells like vessels and tracheids. Conversely, phloem is responsible for the bidirectional translocation of prepared food from the leaves to all other parts of the plant. It is primarily made up of living cells.
- (c) The sieve tubes are the main conducting elements in phloem, but they lack a nucleus and have very few organelles to allow the smooth flow of nutrients. Therefore, companion cells are absolutely essential for their survival. Companion cells are highly specialised, closely associated cells containing

a dense cytoplasm and a prominent nucleus that actively regulate the metabolic functions and transport activities of the adjacent sieve tubes.

- 131.** (a) Connective tissues differ widely in their physical consistency; for example, blood is a fluid while bone is extremely hard. How do you explain the biological reason for this difference by describing their respective matrices?
- (b) Furthermore, how do ligaments and tendons differ in their function within the musculoskeletal system?

Ans :

- (a) Connective tissues are diverse because their function directly depends on the nature of their intercellular matrix. Blood acts as a transport medium throughout the body, so it possesses a fluid, watery matrix called plasma, which contains red blood cells, white blood cells, and platelets. This liquid state allows blood to flow freely through vessels to deliver nutrients and oxygen. Conversely, bone forms the structural framework of the body, demanding immense strength. Therefore, it has a rigid, solid matrix heavily embedded with calcium and phosphorus compounds.
- (b) Within the musculoskeletal system, ligaments and tendons serve distinct connective roles. Ligaments are highly elastic and strong tissues that connect one bone to another bone, stabilizing joints and preventing abnormal movements. Tendons are extremely tough, fibrous tissues with limited flexibility that connect muscles to bones, effectively transmitting the muscular force required to produce coordinated skeletal movements.

- 132.** (a) How do you differentiate clearly between voluntary and involuntary movements in animals?
- (b) How can you describe the unique structure and specific location of cardiac muscles?
- (c) Why is it absolutely essential for cardiac muscles to function entirely involuntarily and without experiencing any fatigue?

Ans :

- (a) Voluntary movements are conscious actions that a person can control at will, such as walking or lifting an object, and are executed

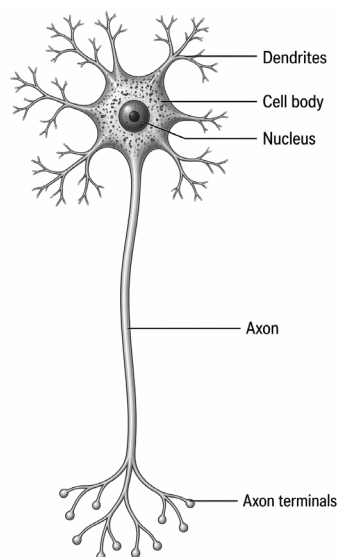
by skeletal muscles. Involuntary movements happen automatically without conscious thought, such as the continuous movement of food through the digestive tract, controlled by smooth muscles.

- (b) Cardiac muscles are a highly specialised type of involuntary tissue found exclusively in the walls of the heart. Structurally, their fibres are cylindrical, distinctly branched, and possess a single central nucleus, showing faint striations under a microscope.
- (c) It is absolutely crucial for cardiac muscles to function involuntarily because the heart must pump blood continuously to supply oxygen to the entire body without requiring conscious effort. Furthermore, they must operate tirelessly without experiencing any fatigue. If cardiac muscles were subject to fatigue like skeletal muscles, the heart would stop beating, leading to immediate death.

- 133.** (a) Can you draw a well-labelled diagram of a typical neuron?
- (b) Using your diagram as a reference, can you explain how the dendrites and the axon work together sequentially to transmit vital messages throughout the nervous system?

Ans :

- (a)



- (b) Nervous tissue comprises highly specialised cells known as neurons, which are explicitly designed to receive stimuli and conduct electrical impulses rapidly across the body. A neuron effectively functions through

the coordinated action of its structural components. The short, highly branched dendrites act as the primary sensory receivers of the neuron. They pick up incoming chemical signals from adjacent neurons or sensory receptors and convert them into an electrical impulse, directing it towards the main cell body. After the cell body processes this signal, the single long nerve fibre, known as the axon, takes over. The axon powerfully conducts the electrical impulse away from the cell body over a long distance. Finally, the signal reaches the axon terminals, which release chemicals to bridge the gap to the next neuron or target muscle, thus perfectly transmitting the vital message to its destination.

- 134.** (a) What mainly constitutes the musculoskeletal system in human beings?
 (b) How do you differentiate between a ball and socket joint and a hinge joint, providing one appropriate example of each?
 (c) Why are fixed joints considered crucial for the protection of the human skull?

Ans :

- (a) The musculoskeletal system is a complex framework primarily composed of bones, skeletal muscles, joints, cartilage, tendons, and ligaments. This integrated system allows humans to stand upright, protects delicate internal organs, and facilitates highly coordinated body movements.
 (b) Joints are critical junctions where two or more bones meet. A ball and socket joint features the rounded head of one bone perfectly fitting into the hollow cup-like depression of another, allowing maximum flexibility and free movement in almost all directions, including complete circular rotation. The human shoulder joint is a classic example. In contrast, a hinge joint restricts movement to a single plane, much like the hinge of a wooden door, allowing only bending and straightening motions, as seen in the elbow joint.
 (c) Fixed joints are rigid connections that permit absolutely no movement. They are essential in the skull to form a protective, unbreakable casing for the brain.

- 135.** (a) What is a lateral meristem and how does it specifically contribute to the formation of annual growth rings in tall trees?
 (b) Can you explain how modern scientists can carefully use these distinct growth rings to interpret and reconstruct the climatic conditions of the past?

Ans :

- (a) The lateral meristem is a specialised tissue consisting of actively dividing cells arranged in a cylindrical ring within the stems and roots of dicot plants. Unlike apical meristems that increase length, the lateral meristem is solely responsible for secondary growth, which continuously increases the diameter or girth of the plant over time. As these cells divide, they produce new layers of tissues both inside and outside the existing structures in a concentric manner. In regions with distinct seasonal changes, this division rate varies throughout the year, creating distinct light and dark bands known as annual growth rings within the tree trunk.
 (b) Scientists carefully study the width and characteristics of these annual rings to extract historical data. Wide rings generally indicate years of abundant rainfall and favourable temperatures, while narrow rings suggest drought conditions, allowing researchers to accurately reconstruct past climatic trends.

CASE BASED QUESTIONS

- 136.** Rahul, a grade nine student, was closely observing his school garden during recess. He noticed the gardener trimming the top shoots of a bushy hedge to give it a neat shape. Surprisingly, after a few weeks, the hedge grew even bushier with many new branches emerging from the nodes of the remaining stems. Curious about plant growth, Rahul also examined a large, freshly cut tree stump nearby and noticed several concentric wooden rings forming its wide diameter. He recalled a science experiment where cutting the extreme tips of onion roots in a water jar completely stopped their downward growth.

QUESTIONS:

- (a) Based on Rahul's observation of the onion root experiment, why did the roots stop growing when their tips were cut?

- (b) Which specific tissue is responsible for the new branches sprouting from the nodes of the trimmed hedge?
- (c) Identify the tissue responsible for the increase in the girth of the tree trunk that led to the formation of the concentric rings.

Ans :

- (a) The roots stopped growing because the apical meristem, which consists of actively dividing cells responsible for increasing the length of the plant, is located at the root tips and was removed when the tips were cut.
- (b) The intercalary meristem, located at the base of leaves or internodes on stems, is responsible for the growth of new branches after the hedge is trimmed.
- (c) The lateral meristem is responsible for increasing the diameter or girth of the stem, resulting in the concentric rings seen on the tree stump.

- 137.** During a summer camp, children were taught how to make natural fiber baskets. The instructor handed out dried coconut husks and fresh, green, flexible twigs from a climbing vine. He showed the students how the fresh twigs could easily bend into tight circles without snapping, unlike dry wooden sticks that broke instantly. He then asked them to extract the tough, rigid fibers from the coconut husk to bind the twigs together. He explained to the children that specific internal cellular structures give the living green twigs their flexibility and the dead husk its immense strength.

QUESTIONS:

- (a) Name the tissue present in the coconut husk that makes it tough and rigid.
- (b) Why are the cells making up the coconut husk tissue considered hard and dead? What chemical is deposited on their walls?
- (c) Which simple permanent tissue allows the fresh green twigs to bend flexibly without breaking?
- (d) Differentiate between the tissue that provides flexibility to the twigs and the most common tissue that stores food in plants.

Ans :

- (a) Sclerenchyma tissue is present in the coconut husk, providing it with strength and rigidity.

- (b) The cells are hard and dead because they have extremely thick walls due to the heavy deposition of lignin, a chemical that acts like cement and makes the structure woody and stiff.
- (c) Collenchyma tissue is responsible for providing flexibility and allowing parts of the plant like stems to bend without breaking.
- (d) Collenchyma tissue consists of living cells with unevenly thickened corners due to pectin deposition, and its main function is flexible support. Parenchyma tissue consists of loosely packed living cells with thin cell walls, and its primary function is the storage of food and sometimes photosynthesis.

- 138.** A team of agricultural scientists was investigating a mysterious wilting disease affecting a large tomato farm. They observed that the soil had adequate moisture, yet the leaves at the top of the plants were drooping and drying out. Upon carefully slicing the stems of the affected plants under a microscope, they discovered that a fungal infection had entirely blocked the inner tubular structures responsible for upward water movement. Meanwhile, the outer tubular structures, which transport synthesized sugars from the leaves down to the roots, remained completely healthy and unaffected by the fungus.

QUESTIONS:

- (a) Identify the two complex permanent tissues mentioned in the scenario as the inner and outer tubular structures.
- (b) Why is the tissue responsible for transporting water categorized as a complex permanent tissue?
- (c) How does the cellular composition of the food-transporting tissue differ from the water-transporting tissue in terms of living and dead cells?
- (d) Predict what would eventually happen to the roots of the plant if the outer tubular structures were blocked instead of the inner ones.

Ans :

- (a) The inner tubular structure is the xylem, and the outer tubular structure is the phloem.
- (b) Xylem is called a complex permanent tissue because it is made up of more than one type of cell working together as a single unit to transport water and minerals.

- (c) Xylem is mostly made up of dead cells like tracheids, vessels, and xylem fibres, with only xylem parenchyma being living. In contrast, phloem is mostly made up of living cells like sieve tubes, companion cells, and phloem parenchyma, with only phloem fibres being dead.
- (d) If the phloem were blocked, the roots would stop receiving the food synthesized by the leaves during photosynthesis. Without nourishment, the root cells would eventually die, leading to the death of the entire plant.

139. On a field trip to a botanical garden, Aisha carefully observed two differently adapted plants. The first was a cactus in the desert section, which had a very thick, waxy coating on its outer green stem and no broad leaves. The second was a water lily floating in a nearby pond, with broad flat leaves resting on the water surface. The guide explained that both plants possess an outermost single layer of cells protecting them, but this layer is uniquely adapted to their specific environments. The guide also pointed out that these outer layers contain tiny pores that facilitate interactions with the atmosphere.

QUESTIONS:

- (a) What is the outermost protective layer of cells on both the cactus and the water lily called?
- (b) Identify the thick waxy coating on the cactus and explain its primary function in a desert habitat.
- (c) Name the tiny pores found on the epidermis of leaves. What essential physiological process do they enable besides gaseous exchange?
- (d) Why would having a very thick waxy coating be disadvantageous for the completely submerged parts of an aquatic plant?

Ans :

- (a) The outermost protective layer of cells on the plants is called the epidermis.
- (b) The thick waxy coating is the cuticle. In a desert habitat, it prevents excessive water loss through evaporation, protecting the plant from drying out.
- (c) The tiny pores are called stomata. Besides gaseous exchange, they enable transpiration, which is the evaporation of water vapours from the plant body that helps in creating a suction pull for water transportation.

- (d) A thick waxy coating prevents the diffusion of water and dissolved gases. For an underwater plant, this would block the direct absorption of dissolved oxygen and carbon dioxide from the surrounding water, which is necessary for respiration and photosynthesis.

140. Dr. Mehta was reviewing the blood test report of a patient complaining of severe weakness, extreme fatigue, frequent throat infections, and a recent paper cut that took exceptionally long to stop bleeding. He explained to the patient that a specific fluid tissue connecting different body parts was malfunctioning. The lab report indicated a significantly lower than normal count of the oxygen-carrying red cells, explaining the weakness. Furthermore, there was an unusual spike in the specialized cells responsible for fighting infections, and a severe deficiency in the tiny cell fragments needed to seal injuries.

QUESTIONS:

- (a) Which major category of animal tissues does blood belong to, and what is its fluid matrix called?
- (b) Identify the specific component of blood responsible for the patient's paper cut bleeding for an exceptionally long time.
- (c) Which specific blood cells are causing the unusual spike to fight off the patient's frequent throat infections?
- (d) Explain why a low count of the oxygen-carrying red cells leads to severe weakness and fatigue in the patient.

Ans :

- (a) Blood belongs to the category of connective tissues, and its fluid matrix is called plasma.
- (b) The patient has a deficiency in platelets, which are the blood components responsible for blood clotting at the site of an injury.
- (c) White Blood Cells are spiking in number to collect at the infected areas and fight off the germs causing the throat infections.
- (d) Red blood cells contain haemoglobin, which transports oxygen to all body tissues. A low count means the muscle and organ cells receive less oxygen for energy production, leading to severe weakness and fatigue.

- 141.** During an intense ten-kilometer marathon, athlete Sunita felt her leg muscles burning and aching, eventually forcing her to slow down due to extreme fatigue. She noticed that she could consciously control her running pace by deciding when to move her limbs faster or slower. However, despite the intense physical exertion, she realized that her heart was beating rapidly and continuously without her having to consciously think about it. Most importantly, she marvelled at the fact that her heart muscle never felt the same exhausting fatigue that forced her legs to stop moving.

QUESTIONS:

- Which type of muscular tissue is present in Sunita's legs that she can consciously control during the run?
- State two structural differences between the muscle cells in her legs and the muscle cells in her heart.
- Why is it biologically essential that cardiac muscles possess the property of contracting continuously without fatigue?

Ans :

- Skeletal muscle, which produces voluntary movements, is present in Sunita's legs.
 - Skeletal muscle fibres in the legs are unbranched and multinucleate. In contrast, cardiac muscle fibres in the heart are branched and have a single nucleus.
 - The heart must pump blood continuously to supply oxygen and nutrients to the entire body throughout a person's life. If cardiac muscles fatigued and stopped contracting like skeletal muscles do, blood circulation would halt, leading to immediate death.
- 142.** In a busy cooking class, Chef Rohan was distracted and accidentally grabbed a scorching hot metal pan with his bare hand. In a fraction of a second, even before he consciously registered the pain, he violently jerked his hand away from the stove. Later that evening, he noticed a small fluid-filled blister forming on the outermost layer of his skin where it had touched the hot metal. The clinic doctor told him that his skin's top layer acts as a vital barrier, while a highly specialized biological wire network running throughout his body was responsible for his lightning-fast reaction to the heat.

QUESTIONS:

- Which tissue forms the outermost layer of Chef Rohan's skin that got blistered, and how are its cells structurally arranged to provide protection?
- Identify the highly specialized tissue network that allowed him to receive the heat sensation and instantly transmit the message to pull his hand away.
- What is the fundamental cellular unit of this communication network called? Name its three main structural parts.
- Explain briefly how the functions of epithelial tissue and nervous tissue fundamentally differ based on this scenario.

Ans :

- Epithelial tissue forms the outermost layer of the skin. Its cells are flat, tightly packed with many layers, and have very little space between them to protect underlying tissues from mechanical injury.
 - The nervous tissue forms the body's control and coordination network responsible for rapid reactions.
 - The fundamental cell of the nervous tissue is called a neuron. Its three main parts are the cell body, dendrites, and axon.
 - Epithelial tissue acts as a physical barrier for protection against injury, fluid loss, and germs. Nervous tissue, on the other hand, is specialized for receiving sensory stimuli and transmitting electrical messages to coordinate body responses.
- 143.** During a competitive football match, a player collided heavily with an opponent and fell to the ground clutching his right knee in immense pain. At the hospital, an X-ray revealed no fractures in the hard, rigid structures supporting his leg. However, a detailed MRI scan showed a severe tear in the tough, elastic connective bands that securely connect his thigh bone to his shin bone to keep the joint stable. The doctor also noted minor wear and tear on the soft, flexible cushioning present at the ends of his leg bones, which usually absorbs shock when he lands from a jump.

QUESTIONS:

- Identify the hard, rigid connective tissue that supports the leg and showed no fractures in the X-ray.

- (b) Name the specific elastic connective tissues that were torn, which connect bone to bone at the knee joint.
- (c) What is the soft, flexible cushioning tissue at the ends of the bones called?
- (d) If the tough bands connecting his calf muscles to his heel bone were injured instead, which connective tissue would be damaged?

Ans :

- (a) Bone is the hard, rigid connective tissue supporting the leg.
- (b) Ligaments are the connective tissues that were torn; they connect bone to bone and provide stability to the joint.
- (c) Cartilage is the soft, flexible tissue that provides cushioning at the ends of bones to absorb shock.
- (d) Tendons would be damaged, as they are the connective tissues responsible for connecting muscles to bones.

- 144.** A classical Indian dancer, Meera, was choreographing a complex new performance. She started her routine with a graceful, full-circle rotation of her arms originating from the shoulders. Next, she bent her elbows and knees sharply in a rhythmic pattern, restricting their movement to only one direction. Finally, she incorporated rapid side-to-side head movements, looking left and right while keeping her torso perfectly still. A biology student in the audience was fascinated by the biomechanics, noting how different anatomical junctions in Meera's skeleton permitted such varied, specific, and beautiful ranges of motion.

QUESTIONS:

- (a) Which specific type of joint allowed Meera to perform a complete forward, backward, and circular rotation of her arms?
- (b) Identify the type of joint present in Meera's elbows and knees that allows bending movement primarily in only one direction.
- (c) Name the joint connecting her skull to her backbone that facilitated her side-to-side head movements like a turning doorknob.
- (d) The flat bones of Meera's skull protect her brain but cannot move relative to one another. What type of joint connects them?

Ans :

- (a) The ball and socket joint in the shoulder allowed for the complete circular rotation of her arms.

- (b) The hinge joint is present in the elbows and knees, restricting movement to one direction similar to a door hinge.
- (c) The pivot joint connects the skull to the backbone, allowing the head to move side to side.
- (d) Fixed joints connect the flat bones of the skull, preventing movement to keep the delicate brain safe.

- 145.** An agricultural research institute was attempting to mass-produce a rare, disease-resistant variety of carrot. Instead of planting normal seeds, a botanist took a tiny fragment of mature, specialized cells from the phloem of a healthy carrot root. He placed these cells in a sterile liquid medium inside a glass flask containing specific nutrients, sugars, and growth hormones. He ensured the mixture was continuously aerated by stirring. Over several weeks, this single mass of specialized cells dedifferentiated, actively divided, and eventually grew into hundreds of identical miniature carrot plantlets ready to be planted in soil.

QUESTIONS:

- (a) What biological term is used to describe the incredible ability of the mature carrot cells to divide and develop into a completely new, entire plant?
- (b) In the context of tissue culture, why was it necessary to place the carrot cells in a nutrient medium containing sugars and hormones instead of pure water?
- (c) According to F.C. Steward's findings, what is the role of dedifferentiation in this experiment?

Ans :

- (a) The term used to describe this ability is totipotency.
- (b) The nutrient medium provides the essential raw materials (like sugars for energy) and chemical signals (hormones) required to trigger cell division and support the rapid growth of the unspecialized cells into a new plant mass. Pure water lacks these necessary components.
- (c) Dedifferentiation allows mature, specialized permanent tissue cells (like phloem) to regain the ability to divide. They form an unspecialized mass of dividing cells, which can then redifferentiate to form roots, shoots, and eventually a whole new plant.

CHAPTER 4

Describing Motion Around Us

SUMMARY

1. REST AND MOTION

If an object does not change its position with time with respect to the surroundings, it is said to be at rest.

If an object changes its position with time with respect to the surroundings or a fixed origin, it is said to be in motion.

Both rest and motion are relative terms.

2. DISTANCE

It is total path length travelled by an object during a given time along a straight line. It does not depend on the direction of motion and it has only the magnitude.

3. DISPLACEMENT

It is the shortest distance travelled by an object from its initial position to final position. It has both magnitude and direction. The magnitude of displacement is equal to the distance covered when an object moves along a straight line in a given direction. However, if the direction of motion changes, then magnitude of displacement is less than the distance covered by the object. The magnitude of displacement can never be more than the distance covered by the moving object.

4. UNIFORM AND NON-UNIFORM MOTION

If an object travels equal distances in equal intervals of time, it is said to be in uniform motion. If an object travels unequal distances in equal intervals of time or equal distances in unequal intervals of time, it is said to be in non-uniform motion.

5. SPEED

It is the distance travelled by an object in unit time.

$$\text{So, speed } (v) = \frac{\text{Distance } (s)}{\text{Time } (t)}$$

The SI unit of speed is metre per second (ms^{-1}). The speed is also measured in km h^{-1} . The CGS unit of speed is cm s^{-1} .

$$1 \text{ km h}^{-1} = \frac{5}{18} \text{ m s}^{-1}$$

Since speed has only the magnitude, i.e., it does not have direction, it is a scalar quantity.

1. **Uniform speed :** If an object travels equal distances in equal intervals of time, it is said to be moving with a uniform speed.
2. **Non-uniform speed :** If an object travels unequal distances in equal intervals of time or equal distances in unequal intervals of time, then it is said to be moving with a non-uniform speed.
3. **Average speed :** It is the ratio of total distance travelled by a moving object and the total time taken to cover that distance.
4. **Instantaneous speed :** It is the speed of an object at a particular instant during its motion. The speedometer of a vehicle measures its instantaneous speed and the odometer of vehicle measures the total distance travelled by the vehicle.

6. VELOCITY

It is the displacement of the moving object per unit time.

$$\begin{aligned}\text{Velocity } (v) &= \frac{\text{Displacement } (s)}{\text{Time } (t)} \\ &= \frac{\text{Distance covered in a given direction}}{\text{Time}}\end{aligned}$$

Velocity is similar to speed, but direction of motion is specified in the case of velocity. Hence, velocity is a vector quantity.

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Magnitude of velocity is same as the speed of an object if the object moves in a straight line along a given direction. In other situations, the magnitude of velocity is less than the speed of a moving object.

1. **Uniform velocity** : If an object travels equal displacements in equal intervals of time, it is said to be moving with a uniform velocity.
2. **Non-uniform velocity** : If an object travels unequal displacements in equal intervals of time or equal displacements in unequal intervals of time, it is said to be moving with a non-uniform velocity.
3. **Average Velocity** : It is the ratio of total displacement and total time taken for that displacement. If the velocity of an object moving along a straight line is uniformly changing, then the average velocity is the arithmetic mean of its initial velocity (u) and final velocity (v) for a given time interval.

Average velocity (v_{av})

$$= \frac{\text{Initial velocity} + \text{Final velocity}}{2}$$

$$= \frac{u + v}{2}$$

The average speed of an object cannot be zero, but its average velocity may be zero, if final position of the object is same as its initial position.

4. **Instantaneous velocity** : It is the velocity of a moving object at a particular instant. It is equal to the instantaneous speed of a moving object.

7. ACCELERATION

It is the rate of change of the velocity of an object. If velocity of an object changes from initial value u to final value (v) in time (t), then

$$\text{Acceleration } (a) = \frac{\text{Change in velocity}}{\text{Time}}$$

$$= \frac{v - u}{t}$$

The SI unit of acceleration is metre (second)⁻² or m s^{-2} . Acceleration is a vector quantity because it has both magnitude and direction. Acceleration is said to be positive if the direction of acceleration is same as the direction of velocity. But acceleration is said to be negative if the direction of acceleration is opposite to the direction of velocity.

1. **Uniform and non-uniform acceleration** : If velocity of an object increases or decreases by equal amounts in equal intervals of time, it is said to be moving with a uniform acceleration. But, if velocity of an object changes by unequal amounts in equal intervals of time, then it is said to be moving with non-uniform acceleration.
2. **Deceleration or retardation** : Retardation is nothing but a negative acceleration. If the velocity of object decreases, the acceleration is said to be negative.

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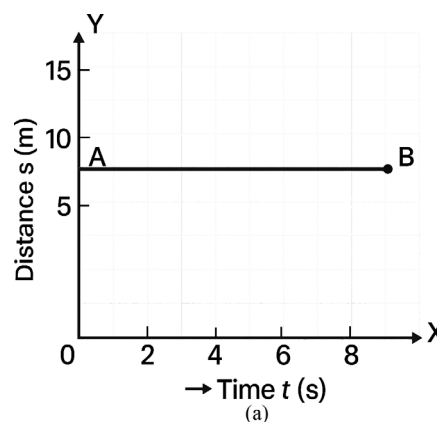
8. GRAPHICAL REPRESENTATION OF MOTION

Motion of an object can be described using line graphs, following graph can be drawn for motion of an object

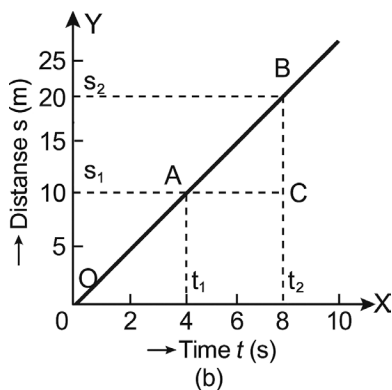
8.1 Distance-Time Graph of An Object

It shows the variation of distance travelled by it with time.

1. For an object at rest, the distance-time graph is a straight line parallel to the time axis as shown Fig(a).



2. For uniform motion along a straight line, the distance-time graph is a straight line which is inclined at a constant angle to the time axis as shown in Fig. (b). The slope of straight line gives the uniform speed of the moving object.



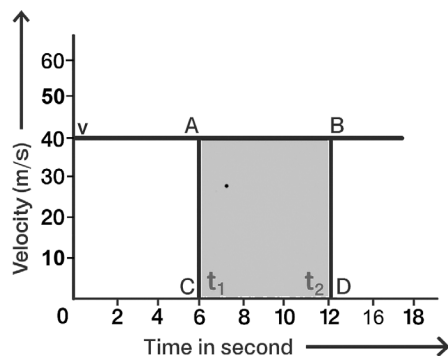
In Fig. (b),

$$\begin{aligned}\text{Uniform speed } (v) &= \frac{\text{Distance travelled } (s_2 - s_1)}{\text{Time } (t_2 - t_1)} \\ &= \frac{BC}{AC} \\ &= \text{Slope of } s-t \text{ graph}\end{aligned}$$

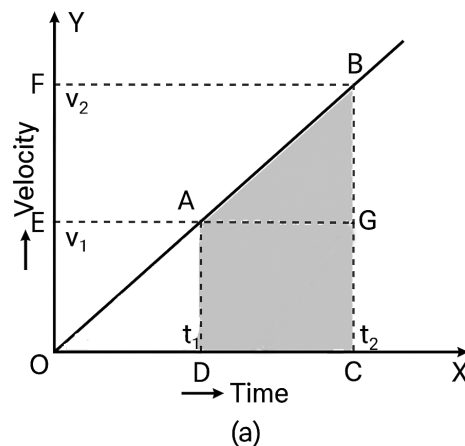
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8.2 Velocity-Time Graph of An Object

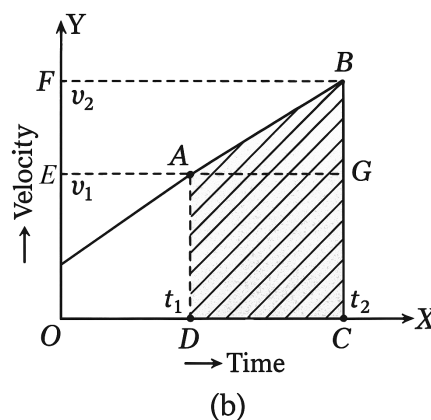
The velocity-time graph of an object for uniform motion along a straight line is a straight line parallel to the time axis as shown in figure. The area under the velocity-time graph gives the magnitude of displacement (or the distance) travelled by the object in the given time.



1. Velocity-time graph of an object for a uniformly accelerated motion is an inclined straight line. If initial velocity of any object is zero, then the graph starts from origin as shown in Fig. (a).



2. But, if initial velocity is finite, then the graph does not pass through origin. For a uniformly accelerated the slope of velocity-time graph gives the value of uniform acceleration of the moving object as shown in Fig. (b).



In Fig. (a) and (b),

$$\begin{aligned}\text{Acceleration } (a) &= \frac{\text{Change in velocity}}{\text{Time}} \\ &= \frac{v_2 - v_1}{t_2 - t_1} = \frac{BG}{AG} \\ &= \text{Slope of } v-t \text{ graph}\end{aligned}$$

3. The area under the velocity-time graph gives the magnitude of displacement (or the distance) travelled by the object during the given time.

9. EQUATIONS OF MOTION

For uniformly accelerated motion of an object along a straight line, we can obtain or derive three equations by correlating its velocity, acceleration and the distance travelled Which are known as equation of motion.

1. For velocity-time relation, (1st equation of motion)

$$v = u + at$$

2. For position-time relation, (2nd equation of motion)

$$s = ut + \frac{1}{2}at^2$$

3. For position-velocity relation, (3rd equation of motion)

$$v^2 - u^2 = 2as$$

10. CIRCULAR MOTION

If an object moves around a fixed point in circular path, then its motion is called circular motion.

11. UNIFORM CIRCULAR MOTION

It is motion of an object along a circular path with a uniform speed. In motion, the speed of a moving object remains constant but its velocity changes continuously with direction of motion. Thus, uniform circular motion is an accelerated motion.

12. CENTRIPETAL ACCELERATION

It is the acceleration of an object undergoing uniform circular motion.

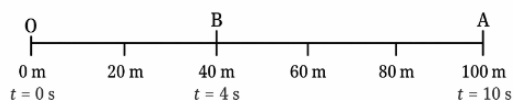
13. REVOLUTION PERIOD (T)

It is the time taken by an object undergoing uniform circular motion to complete one revolution along the circular path. If an object is moving with a constant speed v along a circular path of radius r then

$$\text{Revolution period } (T) = \frac{2\pi r}{v}$$

PAUSE AND PONDER

1. In the example of an athlete running back and forth on a straight track as shown in the figure, when will the displacement of the athlete be zero? What will be the total distance travelled in that case?



Ans :

The displacement of the athlete will be zero when they return to their initial starting point O. In this case, since the athlete ran from point O to point A (100 m) and then all the way back to point O (100 m), the total distance travelled will be 200 m.

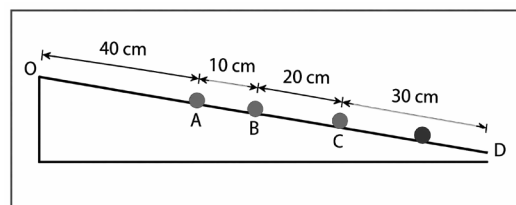
2. Fuel used up in a vehicle depends on which of the following? Justify your answer.

- (i) Total distance travelled
- (ii) Displacement

Ans :

Fuel used up in a vehicle depends on the (i) total distance travelled. This is because the engine must continuously burn fuel to generate energy for every part of the physical path the vehicle moves along, regardless of its direction. Even if a vehicle returns to its starting point resulting in a net displacement of zero, fuel has been constantly consumed throughout the journey to cover the actual distance driven.

3. A ball rolls down an inclined track as shown in Figure. Is its motion, a straight line motion? Assuming the starting point of the ball (O) to be the origin, can its motion from O to D be depicted using a horizontal line as shown in Figure? Are the values of total distance travelled and magnitude of displacement from O equal or different at positions A, B, C and D?



Ans :

Yes, the motion of the ball rolling down the inclined track is a straight line motion because it follows a single linear path downwards. Assuming the starting point O is the origin, its motion can easily be depicted using a horizontal line by simply defining the positive direction along the track and mapping the linear measurements to a straight horizontal axis. Furthermore, because the ball continuously moves in only one forward direction without turning back, the values of total distance travelled and the magnitude of displacement from O will be exactly equal at all positions A, B, C, and D.

4. During a family road trip, you drive 200 km north in three hours. Afterwards, you drive 200 km south in two hours. Find the average speed and average velocity for your entire trip.

Ans :

Leg	Direction	Distance	Displacement	Time
Leg 1	North (+)	200 km	+200 km	3 h
Leg 2	South (-)	200 km	-200 km	2 h
Total	—	400 km	0 km	5 h

$$\begin{aligned}\text{Average Speed} &= \text{Total Distance} \div \text{Total Time} \\ &= 400 \text{ km} \div 5 \text{ h}\end{aligned}$$

$$\text{Average Speed} = 80 \text{ km/h}$$

Average Velocity

$$\begin{aligned}&= \text{Total Displacement} \div \text{Total Time} \\ &= (+200) + (-200) \div 5 \text{ h} \\ &= 0 \text{ km} \div 5 \text{ h}\end{aligned}$$

$$\text{Average Velocity} = 0 \text{ km/h}$$

5. Under what condition(s) is the
- magnitude of average velocity of an object equal to its average speed?
 - magnitude of average velocity of an object zero while its average speed is not zero?

Ans :

- The magnitude of average velocity is equal to average speed only when an object moves in a straight line in a single direction without ever turning back, ensuring that the total distance travelled perfectly equals the magnitude of displacement.
- The average velocity is zero while the average speed is not zero when an object completes a journey where its final position is the same as its starting position. In this scenario, the overall displacement is zero, but the object has still covered a measurable total distance during its movement.

NCERT EXERCISE

1. My father went to a shop from home which is located at a distance of 250 m on a straight road. On reaching there, he discovered that he forgot to carry a cloth bag. He came home to take it, went to the shop again, bought provisions and came back home. How much was the total distance

travelled by him? What was his displacement from home?

Ans :

The total distance travelled is the sum of all the path lengths covered. He went to the shop (250 m), came back home (250 m), went to the shop again (250 m), and finally came back home (250 m).

Total distance

$$= 250 + 250 + 250 + 250 = 1000 \text{ m.}$$

Since his initial position (home) and final position (home) are the same, the net change in his position is zero. Therefore, his displacement from home is 0 m.

2. A student runs from the ground floor to the fourth floor of a school building to collect a book and then comes down to their classroom on the second floor. If the height of each floor is 3 m, find:
- the total vertical distance travelled, and
 - their displacement from the starting point.

Ans :

- The student travels up 4 floors (ground to 4th) and then down 2 floors (4th to 2nd). Total floors covered = 4 + 2 = 6 floors.

Total vertical distance travelled

$$= 6 \text{ floors} \times 3 \text{ m/floor} = 18 \text{ m.}$$

- Displacement is the shortest straight-line distance between the initial and final positions.

The starting point is the ground floor (0 m) and the final point is the second floor (2 floors $\times$ 3 m = 6 m high). Therefore, the displacement is 6 m upwards from the starting point.

3. A girl is riding her scooter and finds that its speedometer reading is constant. Is it possible for her scooter to be accelerating and if so, how?

Ans :

Yes, it is possible for the scooter to be accelerating even if the speedometer reading (which measures only speed) is constant. Acceleration is the rate of change of velocity, and velocity has both magnitude (speed) and direction. If the girl is riding her scooter along a circular or curved path at a constant speed, the direction of her motion is continuously changing. This continuous change in direction means her velocity is changing, which results in the scooter accelerating.

4. A car starts from rest and its velocity reaches 24 m s^{-1} in 6 s. Find the average acceleration and the distance travelled in these 6 s.

Ans :

Given

Initial velocity $u = 0 \text{ ms}^{-1}$ (starts from rest)

Final velocity $v = 24 \text{ ms}^{-1}$

Time $t = 6 \text{ s}$

- (i) Average acceleration

$$\begin{aligned} a &= \frac{v - u}{t} \\ &= \frac{24 - 0}{6} \\ &= 4 \text{ ms}^{-2} \end{aligned}$$

- (ii) Distance travelled

Using the first equation of motion

$$\begin{aligned} s &= ut + \frac{1}{2}at^2 \\ s &= (0)(6) + \frac{1}{2} \times 4 \times (6)^2 \\ &= 0 + 2 \times 36 = 72 \text{ m} \end{aligned}$$

5. A motorbike moving with initial velocity 28 ms^{-1} and constant acceleration stops after travelling 98 m. Find the acceleration of the motorbike and the time taken to come to a stop.

Ans :

Given

Initial velocity $u = 28 \text{ ms}^{-1}$

Final velocity $v = 0 \text{ ms}^{-1}$ (comes to a stop)

Distance $s = 98 \text{ m}$

- (i) Acceleration

Using the equation of motion,

$$\begin{aligned} v^2 &= u^2 + 2as \\ 0^2 &= (28)^2 + 2 \times a \times 98 \\ 0 &= 784 + 196a \\ 196a &= -784 \\ a &= \frac{-784}{196} = -4 \text{ ms}^{-2} \end{aligned}$$

The negative sign indicates deceleration (retardation)

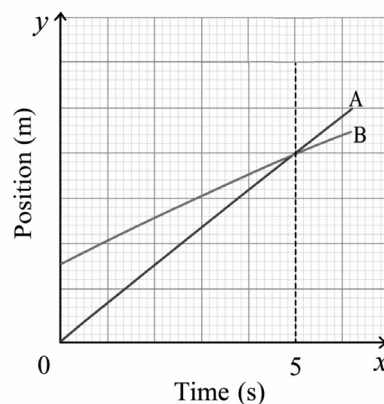
- (ii) Time taken

Using the equation of motion,

$$\begin{aligned} v &= u + at \\ 0 &= 28 + (-4) \times t \\ 4t &= 28 \end{aligned}$$

$$t = \frac{28}{4} = 7 \text{ s}$$

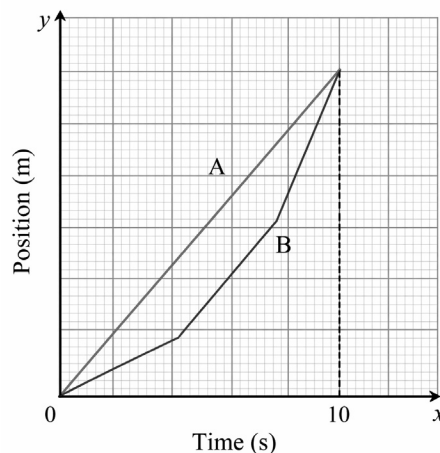
6. Figure shows a position-time graph of two objects A and B that are moving along the parallel tracks in the same direction. Do objects A and B ever have equal velocity? Justify your answer.



Ans :

Based on the position-time graph in figure, objects A and B do not ever have equal velocity. The velocity of an object is given by the slope of its position-time graph. Since the graphs for both objects are straight lines, they are moving with constant velocities. However, the line for object A is steeper than the line for object B, indicating that the slope of A is greater than the slope of B. Because their slopes (velocities) are constant and different from each other throughout the motion, they never have equal velocity.

7. A graph in figure shows the change in position with time for two objects A and B moving in a straight line from 0 to 10 seconds. Choose the correct option(s).



- (i) The average velocity of both over the 10 s time interval is equal since they have the same initial and final positions.
- (ii) The average speeds of both over the 10 s time interval are equal since both cover equal distance in equal time.
- (iii) The average speed of A over the 10 s time interval is lower than that of B since it covers a shorter distance than B in 10 seconds.
- (iv) The average speed of A over the 10 s time interval is greater than that of B since B's speed is lower than A's in some segments.

Ans :

The correct options are (i) and (ii).

According to the graph, both objects start at position 0 at time 0 s and end at the exact same position at time 10 s. Since their initial and final positions are identical, their net displacements are equal. Dividing this equal displacement by the same 10 s time interval gives equal average velocities, confirming option (i). Furthermore, because both objects move in a straight line in one direction without turning back (position only increases), their total distance travelled is equal to the magnitude of their displacement. Since both covered equal total distance in the same time, their average speeds are also equal, confirming option (ii).

8. A truck driver driving at the speed of 54 km h^{-1} notices a road sign with a speed limit of 40 km h^{-1} for trucks. He slows down to 36 km h^{-1} in 36 s. What was the distance travelled by him during this time? Assume the acceleration to be constant while slowing down.

Ans :

Given,

Initial velocity $u = 54 \text{ km h}^{-1}$

Final velocity $v = 36 \text{ km h}^{-1}$

Time $t = 36 \text{ s}$

Converting km h^{-1} to ms^{-1} (multiply by $\frac{5}{18}$)

$$u = 54 \times \frac{5}{18} = 15 \text{ ms}^{-1}$$

$$v = 36 \times \frac{5}{18} = 10 \text{ ms}^{-1}$$

Distance travelled

Using the equation of motion,

$$s = \frac{(u + v)}{2} \times t$$

$$= \frac{(15 + 10)}{2} \times 36$$

$$= \frac{25}{2} \times 36$$

$$= 12.5 \times 36$$

$$= 450 \text{ m}$$

9. A car starts from rest and accelerates uniformly to 20 ms^{-1} in 5 seconds. It then travels at 20 ms^{-1} for 10 seconds and finally applies the brake (with uniform acceleration) to stop in 6 seconds. Find the total distance travelled.

Ans :

The journey has three phases,

Phase I

Acceleration ($u = 0, v = 20 \text{ ms}^{-1}, t = 5 \text{ s}$)

Using, $s = \frac{(u + v)}{2} \times t$

$$s_1 = \frac{(0 + 20)}{2} \times 5$$

$$= 10 \times 5$$

$$= 50 \text{ m}$$

Phase II

Constant velocity ($v = 20 \text{ ms}^{-1}, t = 10 \text{ s}$)

Using, $s = v \times t$

$$s_2 = 20 \times 10$$

$$= 200 \text{ m}$$

Phase III

Deceleration ($u = 20 \text{ ms}^{-1}, v = 0, t = 6 \text{ s}$)

Using, $s = \frac{(u + v)}{2} \times t$

$$s_3 = \frac{(20 + 0)}{2} \times 6$$

$$= 10 \times 6$$

$$= 60 \text{ m}$$

Total Distance,

$$S = s_1 + s_2 + s_3$$

$$= 50 + 200 + 60$$

$$= 310 \text{ m}$$

10. A bus is travelling at 36 km h^{-1} when the driver sees an obstacle 30 m ahead. The driver takes 0.5 seconds to react before pressing the brake. Once the brake is applied, the velocity of the bus reduces with constant acceleration of 2.5 m s^{-2} . Will the bus be able to stop before reaching the obstacle?

Ans :

Given,

$$\begin{aligned}\text{Initial speed, } u &= 36 \text{ km h}^{-1} \\ &= 10 \text{ ms}^{-1}\end{aligned}$$

$$\text{Obstacle distance } d = 30 \text{ m}$$

$$\text{Reaction time } t_r = 0.5 \text{ s}$$

$$\text{Deceleration } a = 2.5 \text{ ms}^{-2}$$

$$\text{Unit conversion, } u = 36 \times \frac{5}{18} = 10 \text{ ms}^{-1}$$

Phase I

Reaction distance (no braking yet, constant speed)

$$\begin{aligned}\text{Using, } s &= u \times t \\ s_1 &= 10 \times 0.5 \\ &= 5 \text{ m}\end{aligned}$$

Phase II

Braking distance ($u = 10 \text{ ms}^{-1}$, $v = 0$, $a = -2.5 \text{ ms}^{-1}$)

$$\begin{aligned}\text{Using, } v^2 &= u^2 + 2as \\ s &= \frac{v^2 - u^2}{2a} \\ s_2 &= \frac{0^2 - 10^2}{2 \times (-2.5)} \\ &= \frac{-100}{-5} \\ &= 20 \text{ m}\end{aligned}$$

Total stopping distance

$$\begin{aligned}S &= s_1 + s_2 \\ &= 5 + 20 \\ &= 25 \text{ m}\end{aligned}$$

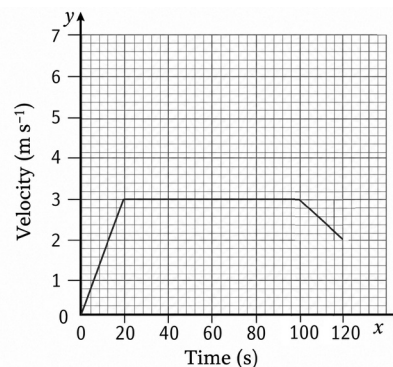
11. A student said, "The Earth moves around the Sun". In this context, discuss whether an object kept on the Earth can be considered to be at rest.

Ans :

Motion is a relative concept, meaning whether an object is at rest or in motion depends on the observer's frame of reference. An object kept on the Earth is at rest with respect to the Earth itself, because its position relative to the Earth's surface does not change with time. However, if that same object is observed from the perspective of the Sun or from space, it is in continuous motion because it revolves around the Sun along with the Earth. Therefore, the object can be considered at rest

relative to the Earth, but it is simultaneously in motion relative to the Sun.

12. The velocity-time graph from 0 s to 120 s for a cyclist is shown in Figure. Shade the areas (in different colours) representing the displacement of the cyclist
- while cyclist is moving with constant velocity.
 - when the velocity of cyclist is decreasing.
- Also, calculate the displacement and average acceleration in the 120 s time interval.



Ans :

From the velocity-time graph:

1. Displacement (area under graph)

Break the graph into parts:

- (i) From 0 to 20 s (velocity increasing)
Triangle:

$$\text{Area} = \frac{1}{2} \times 20 \times 3 = 30 \text{ m}$$

- (ii) From 20 to 100 s (constant velocity)
Rectangle:

$$\text{Area} = 80 \times 3 = 240 \text{ m}$$

- (iii) From 100 to 120 s (velocity decreasing)
Trapezium:

$$\text{Area} = \frac{(3+2)}{2} \times 20 = 50 \text{ m}$$

Total displacement:

$$30 + 240 + 50 = 320 \text{ m}$$

2. Average acceleration

$$\begin{aligned}&= \frac{v - u}{t} \\ &= \frac{2 - 0}{120} = \frac{2}{120} = 0.0167 \text{ m/s}^2\end{aligned}$$

13. A girl is preparing for her first marathon by running on a straight road. She uses a smart watch to calculate her running speed at different intervals. The graph depicts her velocity versus time. Estimate the running distance based on the

graph.

Ans :

Reading the Graph

Phase	Time interval	Velocity	Motion
I	0 – 1 h	$0 \rightarrow 7.5 \text{ km h}^{-1}$	Increasing
II	1 – 5 h	7.5 km h^{-1} (constant)	Constant velocity
III	5 – 6 h	$7.5 \rightarrow 5 \text{ km h}^{-1}$	Decreasing

Distance = Area under the $v - t$ graph. Each phase is treated as a standard geometric shape.

Phase I

(0 – 1 h) — Area of triangle

$$\begin{aligned}
 s_1 &= \frac{1}{2} \times \text{base} \times \text{height} \\
 &= \frac{1}{2} \times 1 \times 7.5 \\
 &= 3.75 \text{ km}
 \end{aligned}$$

Phase II

(1 – 5 h) — Area of rectangle

$$\begin{aligned}
 s_2 &= v \times t \\
 &= 7.5 \times 4 \\
 &= 30 \text{ km}
 \end{aligned}$$

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Phase III

(5 – 6 h) — Area of trapezium

$$\begin{aligned}
 s_3 &= \frac{1}{2} \times (u + v) \times t \\
 &= \frac{1}{2} \times (7.5 + 5) \times 1 \\
 &= \frac{1}{2} \times 12.5 \times 1 \\
 &= 6.25 \text{ km}
 \end{aligned}$$

Total Distance

$$\begin{aligned}
 S &= s_1 + s_2 + s_3 \\
 &= 3.75 + 30 + 6.25 \\
 &= 40 \text{ km}
 \end{aligned}$$

14. On entering a state highway, a car continues to move with a constant velocity of 6 m s^{-1} for 2 minutes and then accelerates with a constant acceleration 1 m s^{-2} for 6 seconds. Find the displacement of the car on the state highway in the 2 min 6 s time interval by drawing a velocity-

time graph for its motion.

Ans :

Given,

Phase I

$$\begin{aligned}
 \text{constant velocity } u &= v \\
 &= 6 \text{ ms}^{-1}, \\
 t_1 &= 2 \text{ min} = 120 \text{ s}
 \end{aligned}$$

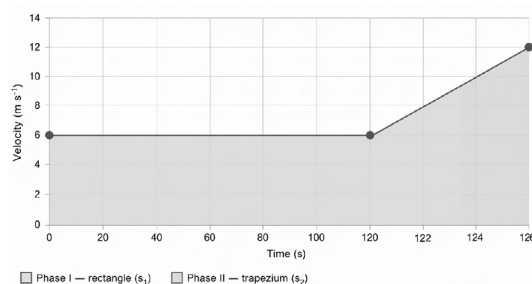
Phase II

$$\begin{aligned}
 \text{acceleration } u &= 6 \text{ ms}^{-1}, \\
 a &= 1 \text{ ms}^{-2} \\
 t_2 &= 6 \text{ s}
 \end{aligned}$$

Final velocity at end of Phase II

$$\begin{aligned}
 v &= u + at \\
 &= 6 + (1 \times 6) \\
 &= 12 \text{ ms}^{-1}
 \end{aligned}$$

Velocity–Time Graph



Displacement = Area under the $v - t$ graph

Phase I (0 – 120 s)

$$\begin{aligned}
 \text{Rectangle } s_1 &= v \times t \\
 &= 6 \times 120 \\
 &= 720 \text{ m}
 \end{aligned}$$

Phase II (120 – 126 s)

$$\begin{aligned}
 \text{Trapezium } s_2 &= \frac{1}{2} \times (u + v) \times t \\
 &= \frac{1}{2} \times (6 + 12) \times 6 \\
 &= \frac{1}{2} \times 18 \times 6 \\
 &= 54 \text{ m}
 \end{aligned}$$

Total Displacement

$$\begin{aligned}
 S &= s_1 + s_2 \\
 &= 720 + 54 \\
 &= 774 \text{ m}
 \end{aligned}$$

15. Two cars A and B start moving with a constant acceleration from rest in a straight line. Car A

attains a velocity of 5 m s^{-1} in 5 s. Car B attains a velocity of 3 m s^{-1} in 10 s. Plot the velocity-time graphs for both the cars in the same graph. Using the graph, calculate the displacement mentioned in the two time intervals (Hint: Calculate the acceleration in both cases. Then calculate their velocities at five instants of time to plot the graph).

Ans :

Acceleration of Each Car

Using, $a = \frac{(v - u)}{t}$ ($u = 0$ for both)

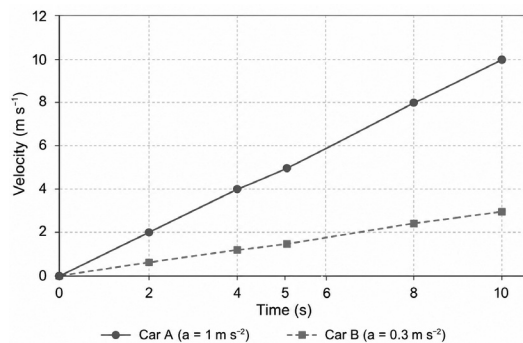
$$a_A = \frac{5}{5} = 1 \text{ ms}^{-2}$$

$$a_B = \frac{3}{10} = 0.3 \text{ ms}^{-2}$$

Velocity at five time instants using $v = at$

Time (s)	Car A ($v = 1 \times t$) (ms^{-1})	Car B ($v = 0.3 \times t$) (ms^{-1})
0	0	0
2	2	0.6
4	4	1.2
6	6 (Car A shown to 10 s)	1.8
8	8	2.4
10	10	3

Velocity–Time Graph



Displacement Area Under the $v - t$ Graph

Car A (0–5 s):

Area of triangle,

$$v \text{ at } 5 \text{ s} = 1 \times 5 = 5 \text{ ms}^{-1}$$

$$s_A = \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times 5 \times 5$$

$$= 12.5 \text{ m (in 5 s)}$$

Car B (0–10 s):

Area of triangle,

$$v \text{ at } 10 \text{ s} = 3 \text{ ms}^{-1}$$

$$s_B = \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times 10 \times 3$$

$$= 15 \text{ m (in 10 s)}$$

16. Rohan studies science from 6 PM to 7:30 PM at home. Consider the tip of the minute's hand of the wall clock. During the given time interval, what is its:

- distance travelled,
- displacement,
- speed, and
- velocity.

The length of the minute's hand is 7 cm.



Ans :

Given,

Length of minute hand

$$r = 7 \text{ cm}$$

Time interval 6:00 PM to 7:30 PM

$$= 1.5 \text{ hours}$$

$$= 90 \text{ min} = 5400 \text{ s}$$

Revolutions completed: 1.5 complete revolutions (minute hand completes 1 revolution per hour)

- (i) Distance Travelled

The tip traces the circumference of circle

$$\text{Distance} = \text{number of revolutions}$$

$$\times \text{circumference}$$

$$\text{Circumference} = 2\pi r$$

$$= 2 \times \frac{22}{7} \times 7 = 44 \text{ cm}$$

$$\text{Distance} = 1.5 \times 44$$

$$= 66 \text{ cm}$$

- (ii) Displacement = shortest is the straight-line distance between the initial and final positions of the tip.

At 6:00 PM, the minute hand points to 12 (top). At 7:30 PM, the minute hand again points to 6 (bottom). These two positions are at diametrically opposite ends of the clock face.

$$\text{Displacement} = \text{diameter}$$

$$\text{Displacement} = 2r$$

$$= 2 \times 7 = 14 \text{ cm}$$

(directed from 12 towards 6, i.e. vertically downward)

Note: After 1 full revolution (at 7:00 PM) the tip returns to 12. In the remaining 30 min it moves to 6 - exactly diametrically opposite to the start.

- (iii) Speed

$$\text{Speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{66}{5400}$$

$$= 0.0122 \text{ cms}^{-1}$$

$$\text{Speed} \approx 0.0122 \text{ cms}^{-1} \text{ (or } \frac{11}{900} \text{ cms}^{-1})$$

- (iv) Velocity

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Total time}}$$

$$= \frac{14}{5400} = 0.002592... \text{ cm s}^{-1}$$

$$\text{Velocity} \approx 0.0026 \text{ cm s}^{-1}$$

(directed from 12 to 6, vertically downward)

OBJECTIVE QUESTIONS

1. Which physical quantity is primarily required to describe the position of an object?
- (A) Only the distance from a fixed point
 (B) Only the direction from a fixed point
 (C) Both distance and direction from a fixed point
 (D) Only the time taken to reach the point

Ans : (C)

To accurately specify the position of an object, you must determine its location relative to a chosen reference point. This requires knowing both the exact distance from the reference point and the specific direction in which the object lies. Neither distance nor direction alone provides a complete description of position.

2. An object is considered to be in motion if its position changes with respect to:

- (A) Its own center of mass over time
 (B) A chosen reference point with time
 (C) The constant speed of the observer
 (D) The total distance travelled by it

Ans : (B)

An object is defined as being in a state of motion when its position continuously changes with respect to a stationary or chosen reference point as time progresses. If the position of the object remains constant relative to this reference point, the object is considered to be at absolute rest.

Match the physical quantities in List-I with their corresponding SI units in List-II.

	List-I		List-II
P.	Displacement	1.	s
Q.	Average speed	2.	m
R.	Average acceleration	3.	m s ⁻¹
S.	Time interval	4.	m s ⁻²

(A) P-2, Q-3, R-4, S-1

(B) P-3, Q-2, R-4, S-1

(C) P-2, Q-4, R-3, S-1

(D) P-4, Q-3, R-2, S-1

Ans : (A)

Displacement is a measure of length, so its SI unit is the metre. Average speed represents distance covered per unit time, resulting in metres per second. Average acceleration signifies the rate of change of velocity, measured in metres per second squared. Time interval is conventionally measured in fundamental seconds.

4. **Assertion (A):** The displacement of an object can be zero even if it has covered a non-zero distance.
Reason (R): Displacement is the net change in position, which becomes zero if the object returns to its initial starting point.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

Displacement measures the shortest distance between the initial and final positions. When a moving object completes a journey and returns

exactly to its starting point, the initial and final positions coincide. Consequently, the net change in position is zero, making the displacement zero despite a non-zero total distance covered.

5. Consider the following statements regarding motion in a straight line:
1. The direction of motion is indicated by positive and negative signs.
 2. The total distance travelled is always equal to the magnitude of displacement.
 3. The choice of origin and positive direction can be made as per convenience.

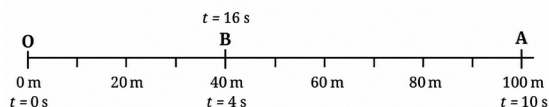
Select the correct combination:

- (A) 1 and 2 only
 (B) 2 and 3 only
 (C) 1 and 3 only
 (D) 1, 2 and 3

Ans : (C)

For straight-line motion, positive and negative signs effectively denote the two possible directions. The origin and positive direction can be chosen conveniently. However, distance equals the magnitude of displacement only if the object moves continuously in one direction without turning back. Therefore, the second statement is not universally true.

6. An athlete starts at the origin (0 m) at $t=0$ s, runs forward to the 100 m mark at $t=10$ s, and then runs backward along the same track, reaching the 40 m mark at $t=16$ s. What is the magnitude of the displacement and the total distance travelled by the athlete at $t=16$ s?



- (A) Displacement: 160 m, Distance: 40 m
 (B) Displacement: 40 m, Distance: 160 m
 (C) Displacement: 100 m, Distance: 60 m
 (D) Displacement: 0 m, Distance: 160 m

Ans : (B)

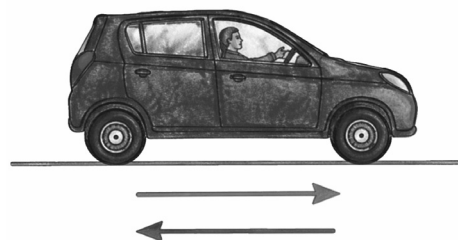
Displacement is the net change in position from the starting point to the final position. The athlete starts at 0 m and ends at 40 m, making the displacement 40 m. The total distance travelled is the sum of the forward path (100 m) and the backward path (60 m), which equals 160 m.

7. An athlete runs on a straight track from point O to point A (100 m) and then turns back to reach point B (40 m from O). What are the distance travelled and the magnitude of displacement, respectively?
- (A) 100 m and 40 m
 (B) 160 m and 40 m
 (C) 140 m and 60 m
 (D) 160 m and 60 m

Ans : (B)

The athlete travels from O to A, covering a distance of one hundred metres. Then, moving from A back to B, the distance covered is sixty metres. The total distance is one hundred plus sixty, equaling one hundred sixty metres. The displacement is the final position B minus origin O, which is forty metres.

8. The diagram represents a car moving in a straight line while applying its brakes. Two vectors are shown above the car. If the forward-pointing vector represents the direction of the car's motion, what physical quantities do the forward and backward vectors represent respectively?



- (A) Forward represents velocity, backward represents acceleration
 (B) Forward represents acceleration, backward represents velocity
 (C) Forward represents displacement, backward represents average speed
 (D) Forward represents average speed, backward represents displacement

Ans : (A)

When an object moves in a straight line and its speed decreases, it experiences deceleration. The velocity vector aligns with the direction of the object's forward motion. However, the acceleration vector points in the opposite direction because the rate of change of velocity is negative relative to the forward movement.

9. Which of the following statements correctly differentiates between distance and displacement?
- (A) Distance requires both magnitude and direction, whereas displacement requires only magnitude.
 - (B) The magnitude of displacement can never be greater than the total distance travelled.
 - (C) Distance can be zero for a moving object, but displacement is always positive.
 - (D) Displacement is a scalar quantity, while distance is a vector quantity.

Ans : (B)

Distance is the total path length covered by an object and is always positive or zero. Displacement is the shortest straight-line distance between the initial and final positions. The magnitude of displacement is always less than or equal to the total distance travelled, never greater, because a straight line is the shortest path.

10. How is the average speed of an object calculated?
- (A) The total distance travelled multiplied by the total time taken
 - (B) The change in position divided by the total time taken
 - (C) The total distance travelled divided by the time interval
 - (D) The final velocity minus the initial velocity divided by time

Ans : (C)

The average speed of an object gives a measure of how fast or slow it is moving over a period. It is mathematically defined as the total distance travelled by the object divided by the total time interval taken to cover that specific distance. It provides no information regarding direction.

11. **Assertion (A):** Average velocity can be negative, zero, or positive.
Reason (R): Average speed has only a numerical value and no direction.
- (A) Both A and R are true and R is the correct explanation of A
 - (B) Both A and R are true but R is not the correct explanation of A
 - (C) A is true but R is false
 - (D) A is false but R is true

Ans : (B)

Average velocity depends on displacement, which can be positive, negative, or zero depending on the final position relative to the initial position.

Average speed depends on distance, possessing only magnitude and no direction. Both statements are factually correct individually, but the nature of average speed does not explain average velocity.

12. Under what condition is the magnitude of the average velocity of an object strictly equal to its average speed?
- (A) When the object moves in a circular path with constant speed
 - (B) When the object moves in a straight line without reversing its direction
 - (C) When the object moves with a constant acceleration in any path
 - (D) When the object returns to its starting point after some time

Ans : (B)

Average speed equals total distance divided by time, while average velocity equals displacement divided by time. The magnitude of displacement perfectly equals the total distance travelled only when the object moves continuously along a straight line in a single direction without turning back. Under this condition, their magnitudes match perfectly.

13. Read the following statements about uniform and non-uniform motion:
1. An object covering equal distances in equal time intervals is in uniform motion.
 2. In non-uniform motion, an object covers unequal distances in equal time intervals.
 3. An object moving with increasing speed is in uniform motion.
 4. An object at a constant speed in a straight line is in uniform motion.

Select the correct combination of true statements:

- (A) 1, 2, and 4
- (B) 1, 3, and 4
- (C) 2, 3, and 4
- (D) 1, 2, and 3

Ans : (A)

Uniform motion is defined by an object covering equal distances in equal intervals of time, which implies maintaining a constant speed in a straight line. Non-uniform motion involves covering unequal distances in equal time intervals. If an object is increasing its speed, it is in non-uniform motion, making statement three completely incorrect.

14. Based on the table tracking an athlete's motion along a straight track, which conclusion about distance and displacement is correct?

Time (t)	Position from Origin (x)	Total Distance (m)	Displacement (m)
0 s	0 m	0 m	0 m
5 s	40 m	40 m	40 m
10 s	80 m	80 m	80 m
15 s	40 m	120 m	40 m
20 s	0 m	160 m	0 m

- (A) Displacement can exceed the total distance travelled by the athlete.
 (B) Total distance and total displacement always maintain identical magnitudes.
 (C) Displacement becomes zero when the athlete returns to the original starting point.
 (D) Total distance decreases when the athlete turns back toward the initial position.

Ans : (C)

Displacement represents the net change in position from an initial starting point. When the athlete returns to the origin at the final timestamp, the initial and final positions are identical, making the displacement zero. Conversely, the total distance continuously increases because it measures the actual path length covered regardless of direction.

15. The concept that an object's speed is the distance travelled divided by the time taken was well-established in ancient India. In which 5th-century treatise is this concept evident?
 (A) Surya Siddhanta
 (B) Aryabhatiya
 (C) Ganitakaumudi
 (D) Lilavati

Ans : (B)

The mathematical concept defining speed as the total distance travelled divided by the time taken was well-understood in ancient Indian scientific literature. This specific understanding of motion and speed is prominently documented in the Aryabhatiya, a highly significant astronomical and mathematical treatise written during the fifth century of the Common Era.

16. A boy swims from one end to the other end of a 25 m pool and swims back to the starting point in

50 seconds. What is his average velocity?

- (A) 1 m/s
 (B) 0.5 m/s
 (C) 0 m/s
 (D) 2 m/s

Ans : (C)

The boy starts from one end of the pool, swims to the opposite side, and completely returns to his initial starting point. Because his initial and final positions are identical, his total displacement is exactly zero. Consequently, dividing this zero displacement by the time taken yields an average velocity of zero.

17. Identify the correct sequence of mathematical operations required to calculate the average acceleration of an object from its initial and final velocities.

1. Subtract the initial velocity from the final velocity.
2. Identify the initial velocity, final velocity, and time interval.
3. Divide the change in velocity by the time interval.

Select the correct sequential order:

- (A) 2, 1, 3
 (B) 1, 2, 3
 (C) 2, 3, 1
 (D) 3, 1, 2

Ans : (A)

To calculate the average acceleration, the very first step is to accurately identify the initial velocity, final velocity, and the given time interval. The second step involves subtracting the initial velocity from the final velocity to find the change. Finally, this change is divided by the time interval to obtain acceleration.

18. The physical quantity that measures the rate of change of velocity of an object with respect to time is known as:

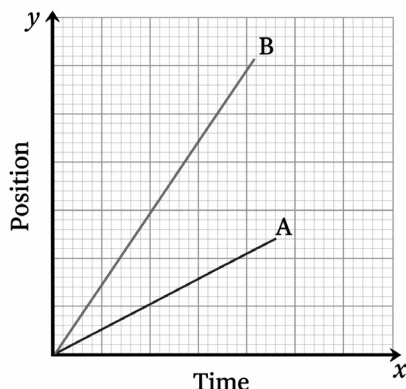
- (A) Average speed
 (B) Displacement
 (C) Average acceleration
 (D) Instantaneous position

Ans : (C)

Average acceleration provides a precise measure of how quickly an object changes its velocity over a specific duration. It is mathematically calculated by determining the difference between the final and initial velocities and dividing that change by

the total time interval. Its standard international unit is meters per second squared.

19. The given position-time graph depicts the motion of two objects, A and B, moving along a straight parallel path. Which of the following statements correctly interprets their motion?



- (A) Object A has a higher velocity than object B because its line covers a wider time span.
 (B) Object B has a higher velocity than object A because its slope on the graph is steeper.
 (C) Both objects are moving with the identical velocity as they both start from the origin.
 (D) Object A is accelerating continuously while object B is moving at a constant speed.

Ans : (B)

In a position-time graph, the slope of the straight line determines the velocity of the moving object. A steeper slope indicates a greater change in position over the same time interval. Since the line for object B is steeper than the line for object A, object B is moving with a higher velocity.

20. For an object moving in a straight line, what does it mean if its average acceleration is in the direction opposite to its velocity?
 (A) The magnitude of its velocity is increasing.
 (B) The magnitude of its velocity is decreasing.
 (C) The object is moving with a constant velocity.
 (D) The object has come to an absolute halt.

Ans : (B)

When an object travels in a straight line, its acceleration and velocity are closely linked. If the acceleration points in a direction completely opposite to the object's current velocity, it indicates that the object is slowing down. In this scenario, the magnitude of the velocity is progressively decreasing over time.

21. A car starts from rest and attains a velocity of 20 m s^{-1} in 10 seconds. What is its average acceleration?
 (A) 200 m s^{-2}
 (B) 20 m s^{-2}
 (C) 2 m s^{-2}
 (D) 0.5 m s^{-2}

Ans : (C)

The car begins its motion from rest, which means its initial velocity is exactly zero. Its final velocity reaches twenty metres per second over a time interval of ten seconds. Using the acceleration formula, we subtract zero from twenty and divide the result by ten, yielding two metres per second squared.

22. When an object is dropped from a height, its velocity increases as it falls. Which of the following statements correctly describes its acceleration?
 (A) The acceleration continuously increases as it falls.
 (B) The acceleration is constant and directed downwards.
 (C) The acceleration is constant and directed upwards.
 (D) The acceleration decreases until it reaches zero.

Ans : (B)

When an object is dropped from a certain height and falls towards the ground, it moves under the influence of gravity. This gravitational force causes the velocity of the falling object to increase steadily. Consequently, the object experiences a constant acceleration directed downwards, commonly denoted by the symbol g .

23. **Assertion (A):** An object can have a very high velocity but zero acceleration.
Reason (R): Acceleration depends on how quickly the velocity is changing, not on the actual magnitude of the velocity.
 (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

Acceleration is defined purely as the rate of change of velocity. If a fast-moving object, like a car cruising on a straight highway, maintains

a perfectly constant velocity, there is no change occurring. Therefore, despite its high speed, the acceleration remains absolutely zero, making the given reason the correct explanation.

24. A student records the overall motion of four remote-controlled cars as shown in the table. Which car has a non-zero average speed but an average velocity of exactly zero?

Car	Initial Position (m)	Final Position (m)	Total Path Length Covered (m)	Total Time Taken (s)
Car P	0 m	50 m	50 m	10 s
Car Q	20 m	20 m	100 m	20 s
Car R	10 m	40 m	30 m	15 s
Car S	50 m	0 m	50 m	25 s

- (A) Car P
(B) Car Q
(C) Car R
(D) Car S

Ans : (B)

Average velocity depends on overall displacement, whereas average speed relies on total path length. Car Q starts and ends at the identical twenty-metre mark, yielding a net displacement of zero and consequently an average velocity of zero. Because it covered a hundred-metre path, its average speed remains strictly non-zero.

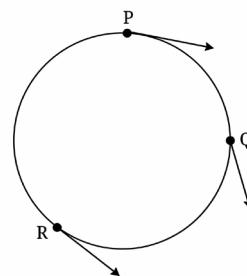
25. In a typical graph representing the motion of a vehicle, which variable is conventionally plotted along the horizontal x-axis?
- (A) Position
(B) Time
(C) Velocity
(D) Acceleration

Ans : (B)

When constructing motion graphs, independent variables are usually placed on the horizontal axis while dependent variables go on the vertical axis. Time flows independently of the object's movement, making it the standard choice for the x-axis. Position, velocity, or acceleration are then

plotted along the y-axis to observe changes over time.

26. An object moves along a circular path at a constant speed. The arrows represent specific vectors at distinct points along the path. Based on this visual representation, which statement correctly describes the nature of the object's motion?



- (A) The motion is unaccelerated because the object's speed remains constant throughout the circular path.
(B) The motion is continuously accelerated because the direction of the velocity changes at every point.
(C) The average velocity for one complete revolution is equal to the constant speed of the object.
(D) The total displacement after one complete revolution is numerically equal to the circle's circumference.

Ans : (B)

Velocity is a vector quantity requiring both magnitude and direction. In uniform circular motion, while the speed remains constant, the direction of motion continuously changes along the tangent at any given point. This continuous change in the direction of velocity dictates that the object undergoes acceleration, making it an accelerated motion.

27. What does a straight line parallel to the time axis on a position-time graph indicate?
- (A) The object is moving with a constant velocity.
(B) The object is moving with a constant acceleration.
(C) The object is stationary and its position is not changing.
(D) The object is returning to its starting point.

Ans : (C)

In a position-time graph, the vertical axis represents the object's position. If the plotted line is perfectly parallel to the horizontal time axis, the vertical value remains completely unchanged as time progresses. This indicates that the object is entirely stationary and maintains a fixed distance from the chosen reference origin.

28. A straight, inclined line passing through the origin on a position-time graph indicates that the object is experiencing:
- Accelerated motion
 - Constant velocity
 - Decreasing speed
 - Zero displacement continuously

Ans : (B)

A straight, inclined line on a position-time graph shows that the object's position changes by exactly equal amounts in equal intervals of time. This linear relationship means the slope of the graph remains perfectly constant. Since the slope represents velocity, the object is moving steadily with a constant velocity.

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29. Consider the following statements about a position-time graph:
- A curved line indicates that the velocity of the object is constant.
 - The slope of the straight line on this graph gives the average velocity.
 - A steeper slope indicates a higher magnitude of velocity.

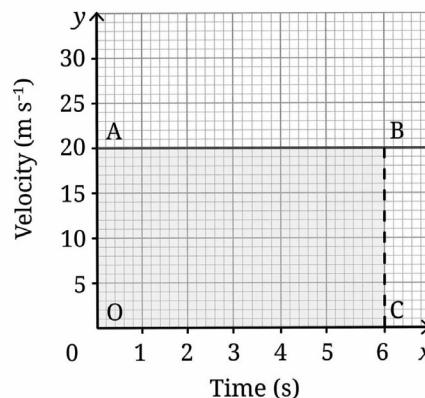
Select the correct combination:

- 1 and 2 only
- 2 and 3 only
- 1 and 3 only
- 1, 2 and 3

Ans : (B)

The slope of a position-time graph directly represents the velocity. A steeper slope signifies a greater change in position over the same time interval, indicating higher velocity. However, a curved line implies that the slope is continually changing, which means the velocity is not constant but is instead undergoing acceleration.

30. The shaded region in the provided velocity-time graph represents the motion of an object travelling on a straight path. What physical quantity is obtained by calculating the area of the shaded rectangle OABC?



- The average acceleration of the object over the time interval.
- The total displacement of the object over the given time interval.
- The instantaneous velocity of the object at the end of the interval.
- The rate of change of velocity of the moving object.

Ans : (B)

The area enclosed by the line on a velocity-time graph and the time axis corresponds to the displacement of the object. For an object moving with constant velocity, this area forms a rectangle. Multiplying the constant velocity by the specific time interval gives the net change in position, yielding total displacement.

31. In a position-time graph, the change in position divided by the change in time calculates the geometric slope. What physical quantity does this slope represent?
- Total distance
 - Average acceleration
 - Average velocity
 - Total time

Ans : (C)

The geometric slope of a line on any graph is calculated by dividing the change in the vertical quantity by the change in the horizontal quantity. For a position-time graph, this involves dividing displacement by the corresponding time interval.

This mathematical ratio specifically defines the physical quantity known as average velocity.

32. The table displays the velocity of a motorcycle recorded at five-second intervals moving in a straight line. During which specific time interval does the motorcycle experience negative acceleration?

Time (s)	Velocity (m s ⁻¹)
0	10
5	15
10	20
15	20
20	15

- (A) From 0 s to 10 s
(B) From 5 s to 15 s
(C) From 10 s to 15 s
(D) From 15 s to

Ans : (D)

Acceleration is defined as the rate of change of velocity over time. A negative acceleration occurs when the magnitude of an object’s velocity decreases over time. The table clearly shows the velocity decreasing from twenty metres per second to fifteen metres per second only between the fifteen and twenty-second marks.

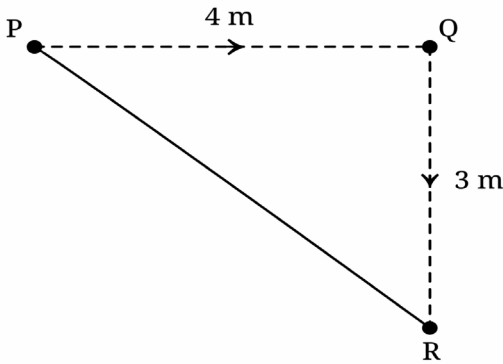
33. Two objects, P and Q, have their motion represented on the same position-time graph. The straight line for P is steeper than the straight line for Q. What can be concluded?
(A) Object P has a lower velocity than Object Q.
(B) Object P has a higher velocity than Object Q.
(C) Both objects have the exact same velocity.
(D) Object Q is accelerating faster than Object P.

Ans : (B)

On a position-time graph, the steepness of a straight line directly correlates to the object’s velocity. A steeper line indicates a larger vertical change in position for a given horizontal time interval. Because object P’s line is noticeably steeper than Q’s line, object P must possess a higher velocity.

34. Based on the provided diagram of an object’s path, what is the ratio of the magnitude of its displacement to the total distance travelled when

moving from point P to point R via point Q?



- (A) $\frac{5}{7}$
(B) $\frac{7}{5}$
(C) 1
(D) $\frac{12}{7}$

Ans : (A)

Distance is the total path length (PQ + QR = 7 m). Displacement is the shortest straight-line distance from the initial to final position, calculated via the Pythagoras theorem ($\sqrt{4^2 + 3^2} = 5$ m). The ratio of displacement magnitude to distance is therefore 5/7. Other options incorrectly flip this ratio or confuse the two quantities.

35. **Assertion (A):** A curved position-time graph indicates that the object is in accelerated motion.
Reason (R): A curved line means the object covers equal distances in equal intervals of time.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

A curved line on a position-time graph clearly shows that the object’s velocity is continually changing, which inherently defines accelerated motion. Therefore, the assertion is correct. However, covering equal distances in equal time intervals represents uniform motion, which corresponds to a straight line, making the provided reason completely false.

36. If an object is moving with a constant velocity, how will its motion be represented on a velocity-time graph?

(A) A straight line passing through the origin with a positive slope
 (B) A straight line parallel to the x-axis
 (C) A parabolic curve starting from the origin
 (D) A straight line with a negative slope

Ans : (B)

When an object moves with a strictly constant velocity, the value of its velocity does not change as time goes on. On a velocity-time graph, this constant vertical value results in a completely horizontal straight line that runs perfectly parallel to the time axis throughout the entire duration of motion.

37. A researcher logs the position of a moving cart at two-second intervals in the table provided. What does this numerical data indicate about the cart's nature of motion?

Time (s)	Position (m)
0	0
2	2
4	8
6	18
8	32

- (A) The cart is moving continuously with a constant velocity.
 (B) The cart is moving continuously with an increasing velocity.
 (C) The cart is moving continuously with a decreasing velocity.
 (D) The cart remains entirely stationary after the two-second mark.

Ans : (B)

The data reveals that the distance covered by the cart in successive two-second intervals continuously increases. It covers two metres initially, then six metres, then ten metres, and fourteen metres. Covering unequal distances in equal time intervals strictly indicates that the object is undergoing accelerated motion with an increasing velocity.

38. What does the slope of a straight line on a velocity-time graph represent?

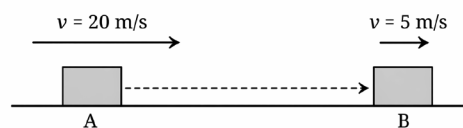
(A) The total distance travelled
 (B) The displacement of the object

- (C) The average acceleration
 (D) The initial velocity

Ans : (C)

To find the slope on a velocity-time graph, you divide the change in the vertical velocity axis by the change in the horizontal time axis. This specific mathematical calculation directly yields the rate at which velocity changes over time. This rate of change is the fundamental definition of average acceleration.

39. The diagram illustrates an object passing through two points on a horizontal surface. Which statement correctly describes the nature of the object's acceleration during this interval?



- (A) The acceleration acts in the same direction as the motion.
 (B) The acceleration acts in the opposite direction to the motion.
 (C) The acceleration is zero because the object continues moving forward.
 (D) The acceleration acts in a vertically downward direction.

Ans : (B)

Acceleration is the rate of change of velocity. When an object's velocity decreases over time (from 20 m/s to 5 m/s), it undergoes retardation or negative acceleration. In such cases, the direction of acceleration is strictly opposite to the direction of motion. Options suggesting forward or zero acceleration contradict the principles of linear deceleration.

40. Arrange the following steps in the correct order to find the displacement from a velocity-time graph showing constant velocity:

1. Identify the time interval on the x-axis.
2. Mark the corresponding constant velocity on the y-axis to form a rectangle.
3. Calculate the area of the enclosed rectangle by multiplying its sides.

Select the correct sequence:

(A) 2, 1, 3

- (B) 1, 2, 3
 (C) 3, 2, 1
 (D) 1, 3, 2

Ans : (B)

To accurately determine displacement from a constant velocity graph, first establish the required time interval along the horizontal axis. Next, observe the corresponding constant velocity to visualize an enclosed rectangular shape on the graph. Finally, calculate the total area of this specific rectangle, as this area numerically equals the displacement.

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41. The table describes the basic motion characteristics of four different objects. Which object represents a case of uniform circular motion, and is it considered an accelerated motion?

Object	Path Shape	Speed	Direction of Motion
Object W	Straight line	Constant	Constant
Object X	Circular	Constant	Continuously changing
Object Y	Straight line	Increasing	Constant
Object Z	Circular	Decreasing	Continuously changing

- (A) Object W; it is not accelerated because its speed remains completely constant.
 (B) Object X; it is accelerated because its direction of motion continuously changes.
 (C) Object Y; it is accelerated because its path speed is strictly increasing over time.
 (D) Object Z; it is not accelerated because it consistently moves in a circular path.

Ans : (B)

Uniform circular motion occurs when an object travels along a circular path at a steady speed. Object X meets these specific criteria. Even though its speed remains strictly constant, the overall velocity changes continuously because the direction of motion alters at every single point, making it a distinctly accelerated motion.

42. A straight line sloping downwards from left to right on a velocity-time graph indicates that the

object is:

- (A) Moving with constant speed in the positive direction
 (B) Moving with decreasing velocity and constant negative acceleration
 (C) Moving with increasing velocity and constant positive acceleration
 (D) Completely stationary and at rest

Ans : (B)

A straight line sloping downwards on a velocity-time graph shows that the vertical velocity value is progressively dropping as time advances. The straight nature of the line indicates that this decrease is occurring at a completely steady rate. This scenario represents motion with a constant negative acceleration, or uniform deceleration.

43. The area enclosed by the velocity-time graph and the time axis over a specific time interval is mathematically equal to which physical quantity?
 (A) Average speed
 (B) Acceleration
 (C) Displacement
 (D) Rate of change of position

Ans : (C)

On a velocity-time graph, the area bounded between the plotted line and the horizontal time axis represents the product of velocity and the time interval. Because velocity multiplied by time directly yields the change in position, this specific geometric area perfectly calculates the total displacement of the moving object.

44. Which of the following kinematic equations correctly relates velocity, initial velocity, acceleration, and time for motion with constant acceleration?

- (A) $s = ut + \frac{1}{2}at^2$
 (B) $v = u + at$
 (C) $v^2 = u^2 + 2as$
 (D) $a = \frac{v+u}{t}$

Ans : (B)

The first fundamental equation of motion mathematically describes how an object's velocity changes over time when subjected to constant acceleration. By algebraically rearranging the basic definition of average acceleration, we obtain the equation where final velocity equals the sum of

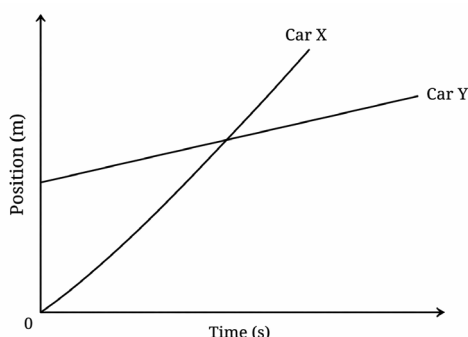
the initial velocity and the product of acceleration and time.

45. When deriving the equation $s = ut + \frac{1}{2}at^2$ from a velocity-time graph, the total area under the graph is calculated by summing the areas of:
- Two different triangles
 - Two different rectangles
 - A rectangle and a triangle
 - A circle and a square

Ans : (C)

For an object accelerating uniformly from an initial non-zero velocity, the region enclosed under its velocity-time graph forms a specific geometric shape called a trapezium. To calculate the total displacement, this complex shape is typically split into a simple lower rectangle and an upper right-angled triangle, whose areas are then added.

46. The graph displays the motion of two vehicles along a straight road. Based on the geometric properties of the graph, which conclusion is definitively correct?



- Car Y is travelling at a higher velocity than Car X.
- Car X has a higher uniform velocity than Car Y.
- Both cars come to rest at the point of intersection.
- Car Y has a constant negative acceleration.

Ans : (B)

The slope of a position-time graph determines the velocity of the object. Car X's line has a steeper slope than Car Y's line, meaning Car X undergoes a greater change in position over the same time interval, thus having a higher velocity. Intersection indicates they share the same position at that instant, not that they stop.

47. The standard kinematic equations (like $v = u + at$) derived in the chapter are strictly valid ONLY when:
- The object moves in a circular path.
 - The velocity of the object remains entirely constant.
 - The acceleration of the object is constant.
 - The object starts its motion from absolute rest.

Ans : (C)

The mathematical derivation of the three fundamental kinematic equations fundamentally relies on the precise assumption that the rate of change of velocity is absolutely steady. Therefore, these specific equations can only be applied to analyze motion scenarios where the object's acceleration remains perfectly constant throughout the entire time interval being considered.

48. Consider the symbols used in the kinematic equations:
- u represents initial velocity.
 - v represents final velocity.
 - a represents average speed.
 - s represents displacement.

Select the combination containing the correct symbol meanings:

- 1, 2, and 4
- 1, 3, and 4
- 2, 3, and 4
- 1, 2, and 3

Ans : (A)

In standard physics notation for kinematic equations, the letter u correctly denotes initial velocity, v denotes final velocity, and s signifies displacement. However, the symbol a is strictly reserved to represent constant acceleration, not average speed. Therefore, the third statement provides an incorrect definition for the widely used symbol a .

49. Which kinematic equation provides a mathematical relationship between position and velocity without requiring the time interval?

- $v = u + at$
- $s = ut + \frac{1}{2}at^2$
- $v^2 = u^2 + 2as$
- $s = \frac{1}{2}(u + v)t$

Ans : (C)

The third primary equation of motion is specifically derived by algebraically eliminating the time variable from the first two basic equations. This creates a highly useful formula linking final velocity, initial velocity, constant acceleration, and total displacement directly, proving advantageous when the total duration of the motion is entirely unknown.

50. Match the shapes of graphs in List-I with the corresponding type of motion in List-II.

	List-I		List-II
P.	Position-time graph: Straight line parallel to time axis	1.	Constant acceleration
Q.	Position-time graph: Straight line inclined to time axis	2.	Constant velocity
R.	Velocity-time graph: Straight line parallel to time axis	3.	Stationary object
S.	Velocity-time graph: Straight line inclined to time axis	4.	Uniformly changing acceleration

- (A) P-3, Q-2, R-2, S-1
 (B) P-2, Q-3, R-1, S-4
 (C) P-3, Q-2, R-1, S-4
 (D) P-1, Q-2, R-3, S-4

Ans : (A)

A horizontal position-time graph means the position is fixed, indicating a stationary object. An inclined position-time graph shows steady movement, meaning constant velocity. A horizontal velocity-time graph confirms the velocity is unchanging, also indicating constant velocity. An inclined velocity-time graph demonstrates a steadily changing velocity, representing constant acceleration motion.

51. A car moving at 15 ms^{-1} applies brakes, producing a constant acceleration of -3 ms^{-2} . How much distance will it travel before stopping?
 (A) 5 m
 (B) 37.5 m
 (C) 75 m
 (D) 22.5 m

Ans : (B)

The initial velocity is fifteen, the final velocity is zero, and acceleration is negative three. We utilize

the third kinematic equation, substituting zero for final velocity squared. This leaves negative two hundred twenty-five equals negative six times displacement. Solving this straightforward algebraic division yields exactly thirty-seven point five metres of stopping distance.

52. **Assertion (A):** In uniform circular motion, the speed of the object is constant, but its velocity continuously changes.

Reason (R): Velocity depends only on the magnitude of motion, which remains constant in a circle.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

In uniform circular motion, an object travels at a steady speed, but its direction of movement alters at every single point along the circular path. Because velocity is a vector quantity demanding both magnitude and specific direction, a changing direction means the velocity continuously changes. Thus, the provided reason is completely false.

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53. An object completes one full revolution in a circular path of radius R in time T . What is the formula for its average speed?

- (A) $v = \frac{R}{T}$
 (B) $v = \frac{2\pi R}{T}$
 (C) $v = \frac{\pi R^2}{T}$
 (D) $v = 0$

Ans : (B)

When an object traverses completely around a circle once, the total distance it covers is perfectly equal to the geometric circumference of that specific circle. The circumference is mathematically defined as two times pi times the radius. Therefore, average speed is this complete distance divided by the total time taken.

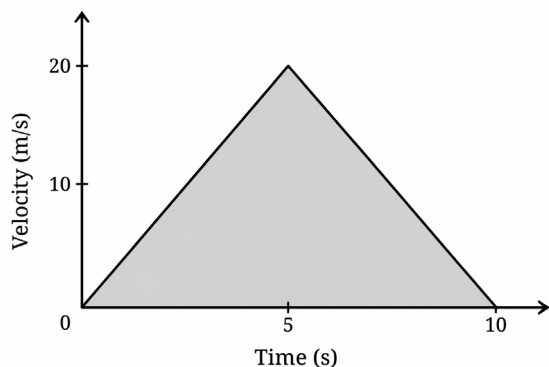
54. A child on a merry-go-round completes exactly one revolution and returns to their starting point. What is their displacement for this specific journey?

(A) Equal to the circumference of the path
 (B) Equal to the diameter of the path
 (C) Zero
 (D) Equal to the radius of the path

Ans : (C)

Displacement specifically measures the shortest straight-line distance directly between an object's initial starting location and its final concluding position. Since the child completes a full revolution and ends up exactly where they initially began, there is no physical gap between the two points, resulting in a net displacement of precisely zero.

55. Analyze the provided velocity-time graph. What does the shaded region represent, and what is its calculated numerical value?



- (A) The average acceleration of the object; 2 ms^{-2}
 (B) The total displacement of the object; 100 m
 (C) The maximum velocity reached; 20 ms
 (D) The total distance travelled; 200 m

Ans : (B)

The displacement of an object is determined by calculating the area enclosed between the velocity-time graph line and the time axis. The shaded region is a triangle. Using the area formula ($\frac{1}{2} \times \text{base} \times \text{height}$), we calculate $\frac{1}{2} \times 10 \text{ s} \times 20 \text{ m/s} = 100 \text{ m}$. The slope, not the area, would yield acceleration.

56. Consider an athlete running uniformly along different closed tracks:

1. On a rectangular track, the direction changes 4 times per round.

2. On a hexagonal track, the direction changes 6 times per round.
 3. On a circular track, the direction changes only 1 time per round.

Select the correct combination:

(A) 1 and 2 only
 (B) 2 and 3 only
 (C) 1 and 3 only
 (D) 1, 2 and 3

Ans : (A)

Running steadily around a rectangular track naturally requires turning corners, causing four distinct direction changes per lap. A hexagonal path demands six specific directional shifts. However, a perfectly circular track represents an infinite number of infinitesimal sides, meaning the athlete's direction of motion changes continuously at every single point, not just once.

57. In uniform circular motion, what indicates the direction of velocity of the object at any specific instant?

(A) A line drawn towards the center of the circle
 (B) A straight line passing through the circle's diameter
 (C) The tangent to the circle at that specific point
 (D) A line drawn parallel to the initial starting point

Ans : (C)

When an object moves continuously along a circular path, its instantaneous direction of travel is always straight ahead relative to its current position. Geometrically, this specific forward direction aligns perfectly with the straight tangent line drawn directly touching the circle at the exact point where the object is located at that moment.

58. If an object moving in a uniform circular path is suddenly released, how will it move immediately after release?

(A) It will spiral inwards towards the center.
 (B) It will move in a straight line along the tangent.
 (C) It will reverse its direction along the same circle.
 (D) It will instantly fall straight downwards due to gravity.

Ans : (B)

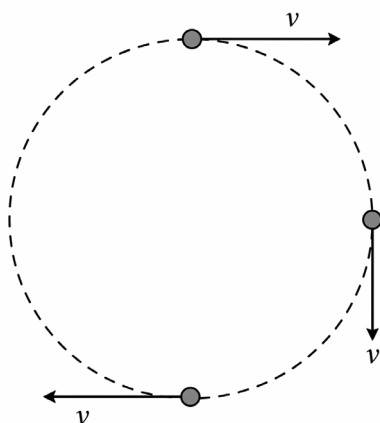
According to basic physical principles, an object tends to maintain its current direction of motion unless constrained. When released from a circular trajectory, the constraining force vanishes. The object simply continues traveling straight ahead in the exact direction it was heading at that specific instant, moving directly along the tangent line.

59. Why is uniform circular motion considered an accelerated motion despite the speed remaining constant?
- Because the radius of the circle constantly changes.
 - Because the direction of velocity continuously changes.
 - Because the object covers unequal distances in equal times.
 - Because the object eventually comes to a complete halt.

Ans : (B)

Acceleration is strictly defined as any change in the velocity vector over time. Velocity comprises both a numerical magnitude and a spatial direction. Although an object in uniform circular motion maintains a perfectly constant speed, its direction of travel changes continuously at every point, meaning its velocity changes, thus constituting acceleration.

60. An object moves along a continuous path as depicted by the vectors at three distinct positions. Which statement correctly categorizes the physical nature of this motion?



- The motion is unaccelerated because the magnitude of velocity remains constant.
- The motion is accelerated because the direction of velocity changes continuously.

- The average velocity of the object over one complete revolution is equal to v .
- The motion represents zero displacement at every recorded position.

Ans : (B)

In uniform circular motion, the object maintains a constant speed, represented by the identical lengths of the velocity vectors. However, because the direction of motion continuously changes tangentially at every point, the velocity itself is not constant. This continuous change in velocity dictates that the motion is fundamentally accelerated, rendering claims of unaccelerated motion incorrect.

61. Which sequence best describes the mathematical derivation of the equation $v^2 = u^2 + 2as$ from the other two kinematic equations?
- Substitute the expression for t into the displacement equation $s = ut + \frac{1}{2}at^2$.
 - Isolate time t from the first equation $v = u + at$.
 - Simplify the resulting algebraic equation to eliminate t entirely.

Select the correct logical sequence:

- 1, 2, 3
- 2, 1, 3
- 3, 1, 2
- 2, 3, 1

Ans : (B)

To derive the third kinematic equation, the initial crucial step is to rearrange the first equation to express time exclusively. Following this, this new expression for time must be carefully substituted directly into the second equation for displacement. Finally, the resulting complex expression is algebraically expanded and simplified to reach the final formula.

62. Arrange the actions required to plot a basic position-time graph from a given data table.
- Draw two perpendicular axes and mark the origin.
 - Connect all plotted points to create the final graph line.
 - Choose a suitable scale for both time and position axes.
 - Plot the individual data points on the graph paper.

Select the correct sequence:

- 1, 3, 4, 2
- 3, 1, 4, 2

- (C) 1, 4, 3, 2
(D) 4, 1, 3, 2

Ans : (A)

When constructing any standard scientific graph, the mandatory first step is properly drawing the perpendicular axes and locating the origin. Secondly, a proportional scale must be strategically chosen to fit the data on the page. Next, individual coordinates are carefully plotted. Lastly, these separate points are systematically connected to form the continuous line.

63. Identify the correct statements regarding the examples of motion in different dimensions:
1. A car moving on a straight highway is in one-dimensional motion.
 2. A planet revolving around the Sun is modeled as two-dimensional circular motion.
 3. A bird flying freely in the sky exhibits three-dimensional motion.
 4. A train on a straight track is an example of two-dimensional motion.

Select the correct combination:

- (A) 1, 2, and 4
(B) 2, 3, and 4
(C) 1, 2, and 3
(D) 1, 3, and 4

Ans : (C)

Movement strictly along a straight highway or straight train track is defined as one-dimensional motion. Therefore, stating a train exhibits two-dimensional motion is factually incorrect. Motion within a flat plane, like a planetary orbit, is two-dimensional. Movement freely through open space, like a flying bird, inherently represents complex three-dimensional motion.

64. When applying brakes to a moving car, the total distance it travels before completely stopping depends heavily on:
- (A) Only the final velocity of the vehicle
(B) Only the constant time of the journey
(C) The initial velocity and the negative acceleration provided
(D) The constant uniform velocity of the vehicle

Ans : (C)

The precise distance a vehicle travels after brakes are engaged is mathematically governed by the third kinematic equation. This crucial stopping distance is directly dependent on the initial velocity the car possessed when braking began,

combined with the specific magnitude of negative acceleration, or deceleration, generated by the friction of the braking system.

65. Which of the following physical quantities is completely specified by just its numerical value (with units) and does NOT require direction?
- (A) Displacement
(B) Average velocity
(C) Acceleration
(D) Total distance travelled

Ans : (D)

In foundational physics, scalar quantities possess solely a magnitude, whereas vector quantities require both magnitude and a specific spatial direction. Displacement, velocity, and acceleration are all vectors because direction is essential to their definition. However, the total distance travelled measures only the overall path length, functioning purely as a scalar quantity requiring no direction.

VERY SHORT ANSWER

66. What is meant by describing the position of an object?

Ans :

Describing the position of an object involves specifying a fixed reference point, along with the distance and direction at any instant of time.

67. Under what condition is an object said to be in a state of rest?

Ans :

An object is said to be at rest if its position with respect to a chosen reference point does not change over time.

68. Define the term displacement of an object in motion.

Ans :

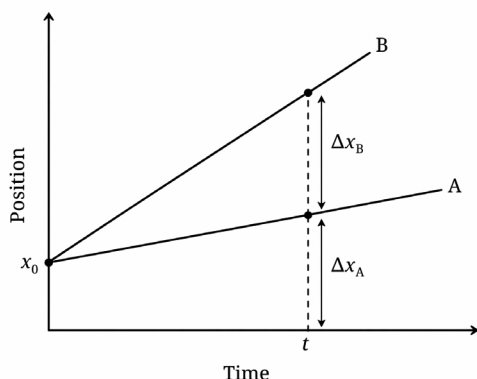
Displacement is defined as the net change in the position of an object between two given instants of time, possessing both magnitude and direction.

69. State one difference between distance and displacement.

Ans :

Distance is the total path travelled requiring only a numerical value, whereas displacement is the

105. Study the given position-time graph.



- Which object, A or B, has a higher magnitude of velocity?
- Justify your answer based on the features of the graph.

Ans :

- Object B definitely possesses a higher magnitude of velocity compared to object A.
- In a position-time graph, the velocity of an object corresponds directly to the slope or steepness of its line. A steeper line signifies a greater rate of change in position over the same duration. Because line B is noticeably steeper than line A, object B covers a significantly larger displacement in the identical time interval. Therefore, object B operates at a higher velocity than object A.

106. Explain why uniform circular motion is considered an accelerated motion even if the object is moving with a constant speed.

Ans :

In uniform circular motion, an object travels along a circular path with a constant speed. However, velocity is a physical quantity that requires both magnitude (speed) and direction. As the object moves along the circle, its direction of motion continuously changes at every single point along the path. Because the direction of velocity is constantly changing, the velocity itself is not constant. This continuous change in velocity with respect to time means that uniform circular motion is always an accelerated motion.

107. Describe the activity using a ring and a marble to demonstrate the direction of velocity of an object moving in a circular path.

Ans :

Place a flat ring, like an adhesive tape ring, on a smooth surface and roll a marble so it rotates along the ring's inner boundary. The marble undergoes circular motion. If you suddenly lift the ring, the marble stops moving in a circle and travels in a straight line instead. This straight-line path is tangential to the circular path at the exact point where the ring was removed. This activity demonstrates that the velocity's direction in circular motion is always along the tangent.

108. Define position and reference point. Why is it necessary to specify a reference point to describe motion?

Ans :

Position is the exact location of an object at any instant of time, specified by a distance and direction from a fixed point. A reference point is this chosen fixed location used as an origin to determine the object's coordinates. Specifying a reference point is essential because motion is a relative concept. An object is considered in motion only if its position changes over time with respect to this specific reference point, otherwise, it remains at rest relative to that observer.

109. What is the difference between average speed and average velocity? Why is average velocity considered a more complete description of an object's motion?

Ans :

Average speed is the total distance travelled divided by the time interval, possessing only magnitude. In contrast, average velocity is the net displacement divided by the time interval, requiring both magnitude and direction. Average velocity provides a more complete description of an object's motion because it specifies how fast the position is changing and in which specific direction. Speed alone cannot indicate where the object is heading, making velocity crucial for understanding complex, real-world motions like navigating to a specific destination.

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83. Write the kinematic equation that relates displacement, initial velocity, time, and acceleration.

Ans :

The primary kinematic equation relating displacement, initial velocity, time, and constant acceleration is formulated as s equals ut plus half at^2 .

84. Correct the statement: "Kinematic equations can be used for any type of accelerated motion."

Ans :

These standard kinematic equations are uniquely valid only for straight-line motion where the acceleration remains completely constant throughout the chosen interval of time.

85. What is uniform circular motion?

Ans :

Uniform circular motion occurs specifically when an object continuously moves along a circular path while maintaining a perfectly constant and unchanging overall speed.

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86. Why is uniform circular motion considered an accelerated motion despite constant speed?

Ans :

It is considered an accelerated motion because the direction of the object's velocity continuously changes at every single point along the curved circular path.

87. What is the direction of velocity of an object in uniform circular motion?

Ans :

The velocity of an object in uniform circular motion is always directed along the tangent drawn to the circular path at that specific point.

88. Give the formula to calculate the average speed of an object completing one circular revolution.

Ans :

For one complete revolution, the average speed is calculated as $2\pi r$ times the radius divided by the total time taken for the trip.

89. What is the result of displacement when an athlete completes exactly one full round on a circular track?

Ans :

The resulting displacement becomes exactly zero because the athlete successfully returns to the original starting point, making the net change in position completely nil.

90. Which ancient Indian text features the concept of calculating speed from distance and time?

Ans :

The comprehensive concept of calculating speed is featured prominently in mathematical texts from ancient India, specifically seen within the fifth-century treatise known as Aryabhatiya.

91. How is instantaneous velocity different from average velocity?

Ans :

Average velocity measures position change over a large time interval, whereas instantaneous velocity specifically describes the velocity of an object at a precise, particular instant.

92. What would happen to a marble moving in a circular ring if the ring is suddenly lifted?

Ans :

If the ring is suddenly lifted, the marble will immediately move away in a straight line corresponding to the tangent of its previous circular path.

93. Give one example of motion in two dimensions from everyday life.

Ans :

A common everyday example of two-dimensional motion in a plane is a kicked football travelling through the air or a vehicle overtaking another car.

94. What is the relationship between the slope of a velocity-time graph and acceleration?

Ans :

The steepness or slope of a straight line on a velocity-time graph directly determines how fast velocity changes, perfectly representing the object's exact uniform acceleration.

diagonally upwards or downwards depending on the velocity's change.

- 124.** Why does the driver of a moving vehicle need to maintain a safe distance from the vehicle ahead? Explain in terms of negative acceleration and reaction time.

Ans :

When a driver suddenly notices a hazard and applies the brakes, the vehicle undergoes negative acceleration to slow down. However, stopping is not instantaneous. The total stopping distance heavily depends on the driver's reaction time—the brief delay before pressing the brake—and the vehicle's braking capacity. During the reaction time, the car continues moving rapidly forward at its initial velocity. Maintaining a safe distance guarantees enough available space for this combined reaction and braking distance, preventing devastating collisions with the vehicle ahead.

- 125.** Trace the sequential steps involved in determining the precise average velocity of a moving object from its position-time graph between two time instants t_1 and t_2 .

Ans :

First, locate the two required time instants, t_1 and t_2 , on the horizontal time axis. Next, trace vertically upwards to find their corresponding points, A and B, precisely on the position-time line graph. Draw horizontal lines from points A and B to the y-axis to read the position values s_1 and s_2 . Finally, calculate the average velocity by dividing the change in position ($s_2 - s_1$) by the elapsed time interval ($t_2 - t_1$). Geometrically, this equals finding the line's slope.

LONG ANSWER QUESTIONS

- 126.** (a) Differentiate between distance travelled and displacement?
 (b) Under what specific condition is the magnitude of average velocity equal to the average speed?
 (c) A boy walks 3 km East, then 4 km North in 2 hours. Calculate his total distance, displacement magnitude, average speed, and average velocity magnitude?

Ans :

- (a) Distance is the total path length covered by an object during its motion, whereas displacement is the shortest straight-line distance measured from the initial to the final position. Distance is a scalar, while displacement is a vector.
 (b) The magnitude of average velocity equals the average speed only when an object moves in a single straight line in one direction without turning back.
 (c) For the walking boy, the distance travelled is the sum of the two paths: $3 \text{ km} + 4 \text{ km} = 7 \text{ km}$.
 His displacement magnitude is calculated using the Pythagorean theorem since he turns North after going East.

$$\begin{aligned}\text{Displacement} &= \sqrt{3^2 + 4^2} \\ &= \sqrt{9 + 16} \\ &= \sqrt{25} = 5 \text{ km}.\end{aligned}$$

Average speed is total distance divided by time:

$$7 \text{ km} / 2 \text{ h} = 3.5 \text{ km h}^{-1}.$$

Average velocity magnitude is displacement divided by time:

$$5 \text{ km} / 2 \text{ h} = 2.5 \text{ km h}^{-1}.$$

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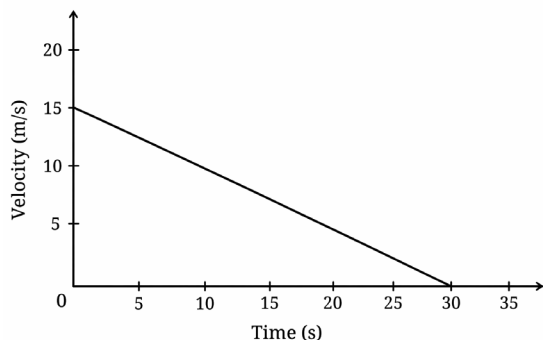
- 127.** (a) Define average acceleration and state its SI unit?
 (b) How do we determine the direction of acceleration for an object moving in a straight line?
 (c) A train starting from rest attains a velocity of 72 km h^{-1} in 5 minutes. Assuming uniform acceleration, find the acceleration and the distance travelled?

Ans :

- (a) Average acceleration is defined as the change in velocity of an object divided by the time interval over which that change occurs. Its SI unit is metre per second squared (m s^{-2}).
 (b) For straight-line motion, if the magnitude of velocity increases, acceleration acts in the same direction as the velocity. If the velocity decreases, acceleration acts opposite to the direction of velocity.

- 101.** Draw a velocity-time graph for an object that is slowing down with uniform acceleration. Explain what the slope of this graph indicates.

Ans :



The drawn graph shows a straight downward-sloping line, representing an object undergoing uniformly decreasing velocity. The slope of any velocity-time graph gives information about the rate at which velocity is changing with time, which is the acceleration. In this specific case, because the line slants downwards, the slope yields a negative mathematical value. This negative slope indicates that the acceleration acts in the opposite direction to the object's movement, effectively acting as a retarding force that slows the object down.

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- 102.** How does the shape of a position-time graph help us determine whether an object is stationary, moving with constant velocity, or moving with changing velocity?

Ans :

The shape of a position-time graph visually indicates the nature of an object's motion. If the graph is a straight line parallel to the time axis, the object's position is not changing, meaning it is stationary. A straight inclined line indicates that the object covers equal distances in equal time intervals, representing constant velocity. On the other hand, if the position-time graph is a curve, it shows that unequal distances are covered in equal intervals, which indicates changing velocity or accelerated motion.

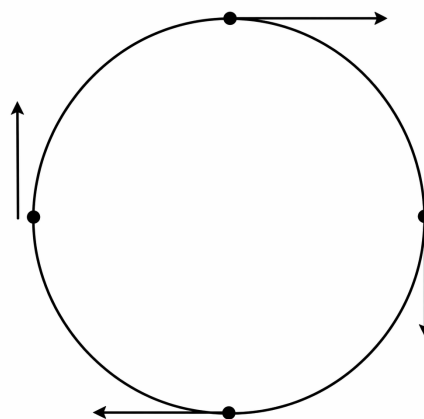
- 103.** State the three kinematic equations for motion in a straight line with constant acceleration. Mention what each symbol represents.

Ans :

The three kinematic equations are $v = u + at$, $s = ut + \frac{1}{2}at^2$, and $v^2 = u^2 + 2as$. In these mathematical expressions, ' u ' represents the initial velocity of the moving object, and ' v ' represents its final velocity at time ' t '. The symbol ' a ' denotes the constant acceleration experienced by the object, while ' s ' stands for the total displacement covered during the given time interval ' t '. These equations help predict the position and velocity of an object at any future time.

- 104.** Draw a diagram showing an athlete running on a circular track. Explain how the direction of velocity changes at different points on the track.

Ans :



When an athlete runs along a circular track, they are exhibiting uniform circular motion. The drawn diagram illustrates that the direction of the athlete's velocity at any given instant is always directed along the tangent to the circle at that exact position. As the athlete progresses along the curved path, the tangential direction continuously shifts. Consequently, even if the athlete maintains a perfectly steady running speed, their velocity is constantly changing due to this endless alteration in their movement direction.

- 114.** What is average acceleration? What does a negative sign in the value of average acceleration indicate?

Ans :

Average acceleration is the change in an object's velocity divided by the time interval during which that change takes place. It measures how quickly the velocity of an object is altering. When calculating this value, a negative sign indicates that the acceleration acts in the direction opposite to the object's initial velocity. In one-dimensional motion, this generally implies that the magnitude of the object's velocity is decreasing over time, a scenario commonly experienced when a moving vehicle applies its brakes to stop.

- 115.** State the formula for the average speed of an object moving in a uniform circular path. Why is the displacement after one complete revolution zero?

Ans :

The average speed for uniform circular motion is calculated using the formula $v = 2\pi R/T$, where R is the radius of the circular path and T is the time taken to complete one full revolution. Displacement measures the shortest straight-line distance between the starting and ending positions. When an object completes exactly one revolution, it returns precisely to its original starting point. Because the initial and final positions are identical, the net change in position, and therefore the displacement, is strictly zero.

- 116.** What happens to an object's speed and velocity during uniform circular motion? Why is this motion called an idealised model?

Ans :

During uniform circular motion, the object's speed remains constant, meaning it covers equal distances along the circumference in equal time intervals. However, its velocity continuously changes because the direction of motion alters at every point on the circular path. This motion is called an idealised model because, in the real world, maintaining perfectly constant speed on a perfectly circular path without any external disturbances is extremely difficult. Yet, it forms the foundation for understanding complex real-world motions like planetary orbits.

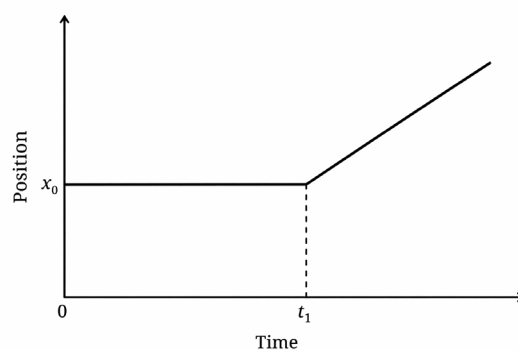
- 117.** What physical quantity is represented by the area enclosed under a velocity-time graph? How is this area calculated for an object starting from rest with uniform acceleration?

Ans :

The area enclosed by the velocity-time graph and the time axis represents the total displacement covered by the moving object within that specific time interval. For an object starting from rest with uniform acceleration, the velocity-time graph is a straight line passing through the origin. The area bounded under this line forms a right-angled triangle. This displacement can be calculated by finding the area of this triangle, using the formula half multiplied by the base (time) and the height (final velocity).

- 118.** Draw a position-time graph showing an object that is stationary for some time and then moves with constant velocity. Why is the graph for a stationary object a horizontal line parallel to the time axis?

Ans :



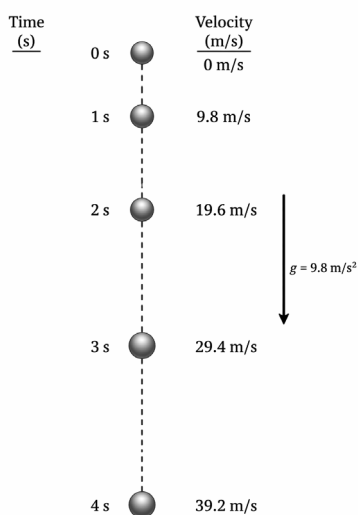
The drawn graph begins with a horizontal segment, which denotes that the object's position coordinate is not changing despite the passage of time. A stationary object simply remains exactly at its fixed location relative to the reference point. Therefore, as time values advance along the x-axis, the position value on the y-axis stays constantly identical. This mathematical relationship inherently produces a perfectly flat, horizontal line that runs parallel to the time axis on the coordinate graph.

- 110.** Define uniform and non-uniform motion in a straight line. Give one example of each from everyday life.

Ans :

Uniform motion occurs when an object travels equal distances in equal intervals of time along a straight line. An example is a car driving steadily at exactly 60 km/h on an empty, straight highway. Non-uniform motion occurs when an object travels unequal distances in equal intervals of time, indicating changing speed. An example is a train departing from a station, where its speed continuously increases as it moves forward, or a bicycle slowing down when approaching a crowded intersection.

- 111.** The given diagram shows an object dropped from a height.



- (a) Is the acceleration of this falling object constant or changing?
 (b) What is the direction of acceleration relative to its velocity?

Ans :

- (a) The acceleration of the falling object remains perfectly constant throughout its descent. The velocity increases by precisely 9.8 m/s during every single successive second interval.
 (b) Since the magnitude of the object's velocity is continually increasing as it falls downwards, the acceleration must be acting in the exact same direction as the object's velocity. Both the velocity and this gravitational acceleration

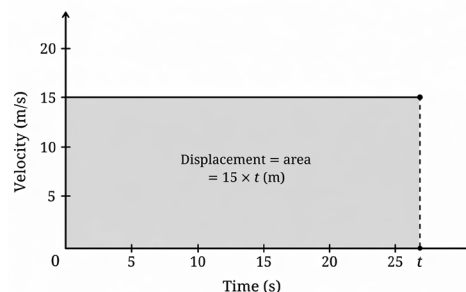
point vertically downwards towards the earth. This causes the object to speed up uniformly as it drops.

- 112.** What does the slope of a position-time graph represent? How will the slopes differ for a fast-moving and a slow-moving object?

Ans :

The slope of a position-time graph represents the rate of change of position, which is the magnitude of the object's average velocity. It is calculated by dividing the change in position by the change in time. The steepness of this slope directly reflects the object's speed. A fast-moving object covers more distance in less time, resulting in a much steeper slope on the graph. Conversely, a slow-moving object covers less distance in the same time, producing a flatter, less steep slope.

- 113.** The diagram below shows a velocity-time graph.



- (a) Identify the exact type of motion shown in this graph.
 (b) How can you calculate the displacement from this graph?

Ans :

- (a) The graph displays uniform motion in a straight line, which means the object is travelling with a constant, unchanging velocity. Its acceleration is absolutely zero.
 (b) You can calculate the total displacement by determining the geometric area enclosed between the horizontal velocity line and the time axis for the chosen interval. Because the line is horizontal, this enclosed shape forms a simple rectangle. Multiplying the rectangle's length (time interval) by its height (velocity magnitude) directly yields the total displacement.

net position change requiring both magnitude and direction.

70. What is the SI unit of average velocity and average speed?

Ans :

The standard international unit for measuring both average speed and average velocity is metre per second, which is represented as m s^{-1} or m/s .

71. Write the formula for calculating the average speed of an object.

Ans :

The average speed of a moving object is calculated by dividing the total distance travelled by the total time interval taken to cover it.

72. What is meant by uniform motion in a straight line?

Ans :

Uniform motion in a straight line occurs when an object covers equal distances in exactly equal intervals of time, maintaining a completely constant speed.

73. Under what condition is the magnitude of average velocity equal to average speed?

Ans :

The magnitude of average velocity equals the average speed strictly when an object moves in a single straight line without turning back or changing direction.

74. Define the average acceleration of an object over a time interval.

Ans :

Average acceleration is defined as the total change in the velocity of an object divided by the specific time interval during which it occurs.

75. What is the SI unit of average acceleration?

Ans :

The SI unit of average acceleration is metre per second squared, which is mathematically represented as m s^{-2} or m/s^2 in scientific contexts.

76. What causes the negative sign in acceleration when a vehicle brakes?

Ans :

The negative sign indicates that the acceleration is acting directly opposite to the direction of

velocity because the magnitude of the velocity is rapidly decreasing.

77. What would you observe about an object's acceleration if its velocity is perfectly constant?

Ans :

If an object moves with a perfectly constant velocity along a straight line, you will observe that its average acceleration remains exactly at zero.

78. What is the significance of the slope in a position-time graph?

Ans :

The slope of a line on a position-time graph is highly significant because it directly provides the magnitude of the average velocity of the object.

79. What does a curved line on a position-time graph indicate?

Ans :

A curved line on a position-time graph clearly indicates that the velocity of the object is not constant, representing an accelerated or non-uniform motion.

80. What does a perfectly straight line parallel to the time axis on a position-time graph represent?

Ans :

A perfectly straight line parallel to the time axis on a position-time graph represents a completely stationary object that remains entirely at rest over time.

81. What is the significance of the area enclosed under a velocity-time graph?

Ans :

The area enclosed by the line on a velocity-time graph and the time axis accurately represents the total displacement of the object within that interval.

82. What is the relationship represented by the first kinematic equation of motion?

Ans :

The first kinematic equation, v equals u plus at , mathematically relates final velocity, initial velocity, constant acceleration, and time interval for an object in motion.

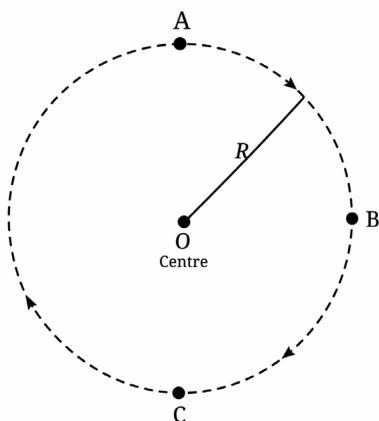
119. Compare distance and displacement with respect to direction dependence and their values when an object completely returns to its initial starting point.

Ans :

Distance is a scalar quantity that measures the total path length covered by an object and requires absolutely no direction for its description. Conversely, displacement is a vector quantity measuring the net positional change, heavily relying on a specified direction from origin. When an object completes a journey and returns precisely to its initial starting point, the total distance measured will be a large non-zero positive number. However, because the initial and final positions coincide, the net displacement becomes exactly zero.

120. Draw a diagram of a merry-go-round showing a child's circular path. If the child takes time T for one revolution of radius R , how do you find their average speed, and why is the velocity continuously changing?

Ans :



When a child rides a merry-go-round, they travel a total distance equal to the circle's circumference ($2\pi R$) in one complete revolution taking time T . Their average speed is simply calculated using the formula $v = 2\pi R/T$. Although this calculated speed remains completely steady, the child's velocity continuously changes. This occurs because velocity is a vector. As the merry-go-round rotates, the specific direction the child is facing and moving constantly shifts at every single point along the circular path.

121. A student says that a car moving at a high constant speed of 100 km/h on a perfectly straight highway has zero acceleration. Is this correct? Justify using the concept of acceleration.

Ans :

Yes, the student's statement is completely correct. Acceleration is scientifically defined as the rate of change of velocity over time. Velocity incorporates both the magnitude (speed) and the specific direction of the motion. If the car is moving on a perfectly straight highway at a steady 100 km/h, neither its speed nor its direction of travel is altering. Because there is absolutely no change in the car's velocity, the calculated acceleration must be identically zero, regardless of how fast it moves.

122. Renu claims that for motion in a straight line, the magnitude of average velocity can never be greater than the average speed. Do you agree? Justify your answer.

Ans :

Yes, I strongly agree with Renu's claim. Average speed is calculated using the total distance travelled, while average velocity utilizes the net displacement. Displacement is fundamentally defined as the shortest straight-line path between initial and final positions. Therefore, the magnitude of displacement can only be equal to or less than the actual total distance covered. Because displacement can never exceed distance, the resulting average velocity magnitude can logically never be greater than the calculated average speed for any given time interval.

123. Compare uniform motion and uniformly accelerated motion in a straight line with respect to the shape of their velocity-time graphs and their respective acceleration values.

Ans :

In uniform motion, an object maintains a constant speed and direction, meaning its acceleration value is entirely zero. The resulting velocity-time graph is a perfectly horizontal straight line parallel to the time axis. In uniformly accelerated motion, the object's velocity increases or decreases by equal amounts in equal time intervals, resulting in a constant, non-zero acceleration value. Consequently, its velocity-time graph visually appears as a straight, inclined line sloping

95. What is the scientific term for the acceleration caused by the Earth's gravitational force?

Ans :

The specific acceleration experienced by freely falling objects due to the Earth's gravitational pull is scientifically termed as acceleration due to gravity, denoted by g .

SHORT ANSWER QUESTIONS

96. Explain with an example how the magnitude of displacement can be zero even if the distance travelled is not zero.

Ans :

Displacement is the net change in an object's position between its initial and final points, while distance is the total path length covered. If an athlete runs one complete round on a circular track and returns to the exact starting line, the total distance travelled equals the track's circumference. However, because the initial and final positions are identical, the net change in position is zero. Therefore, the displacement is zero despite a significant non-zero distance being travelled by the athlete.

97. Explain how the average velocity of an object can be zero while its average speed is non-zero, using a daily life example.

Ans :

Average velocity is calculated as total displacement divided by time, whereas average speed is total distance divided by time. If you travel from your home to school and return home along the same path, your total displacement is zero since your starting and stopping points are identical. Consequently, your average velocity for the entire trip is zero. However, your average speed will be non-zero because you covered a specific total distance going to the school and coming back during that time interval.

98. Describe what is meant by average acceleration. State its SI unit and the condition under which it acts opposite to the direction of motion.

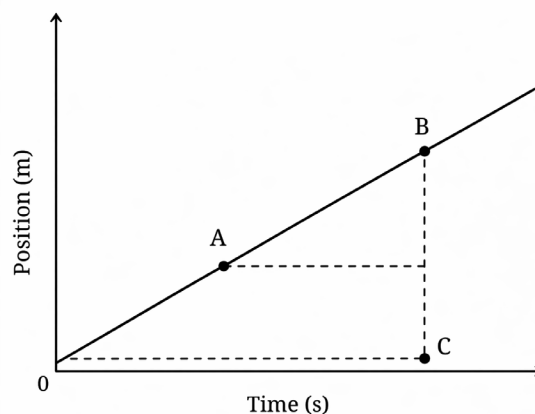
Ans :

Average acceleration is defined as the change in an object's velocity divided by the time interval over which that change occurs. Its SI unit is metre

per second squared (ms^{-2}). Acceleration possesses both magnitude and direction. It acts opposite to the direction of motion when the magnitude of the object's velocity is decreasing. For instance, when a driver applies the brakes to a moving car, the velocity decreases, resulting in negative acceleration acting in the direction opposite to the car's movement.

99. Draw a position-time graph for an object moving with a constant positive velocity. Explain how you can find the velocity from this graph.

Ans :



To find the velocity from this position-time graph, you must calculate the slope of the straight line. You can select any two distinct points on the graph, such as A and B. By drawing lines parallel to the axes, form a triangle. The vertical side represents the change in position, while the horizontal side represents the change in time. Dividing the position change by the time change gives the slope, which equals the object's constant average velocity.

100. Explain how you can calculate the displacement of an object moving with constant acceleration from its velocity-time graph.

Ans :

To calculate the displacement of an object from its velocity-time graph, you must determine the area enclosed by the velocity-time line and the time axis for the given time interval. For constant acceleration, the graph is a straight inclined line. The area under this line typically forms a trapezium. By dropping perpendiculars to the time axis from the initial and final time points, you can calculate the total area as the sum of a rectangle and a triangle, which equals the total displacement.

- (c) For the train, initial velocity

$$u = 0 \text{ m s}^{-1}$$

Final velocity

$$v = 72 \text{ km h}^{-1}$$

$$= 72 \times (5/18) = 20 \text{ m s}^{-1}$$

Time $t = 5 \text{ minutes} = 300 \text{ s}$

Acceleration

$$a = (v - u)/t$$

$$= (20 - 0)/300$$

$$= 1/15 \text{ m s}^{-2}$$

$$\approx 0.067 \text{ m s}^{-2}$$

Using the equation

$$s = ut + \frac{1}{2} at^2$$

$$s = 0(300) + 0.5 \times (1/15) \times (300)^2$$

$$s = 0.5 \times (1/15) \times 90000$$

$$s = 3000 \text{ m or } 3 \text{ km.}$$

The train travels 3 km.

- 128.** (a) Write the three kinematic equations for motion in a straight line with constant acceleration?
- (b) Why are these equations not applicable for an object moving in a circular path at a constant speed?
- (c) A car travelling at 90 km h^{-1} applies brakes, producing a constant acceleration of -0.5 m s^{-2} . How far will it go before stopping?

Ans :

- (a) The three kinematic equations for motion in a straight line with constant acceleration are:

$$v = u + at$$

$$s = ut + \frac{1}{2} at^2$$

$$\text{and } v^2 = u^2 + 2as.$$

- (b) These equations are valid only when acceleration remains constant in both magnitude and direction. In uniform circular motion, although the speed is constant, the direction of motion changes continuously. Consequently, the velocity and acceleration change direction at every single point, meaning acceleration is not constant, rendering these equations strictly invalid for circular paths.

- (c) For the braking car:

Initial velocity

$$u = 90 \text{ km h}^{-1}$$

$$= 90 \times (5/18)$$

$$= 25 \text{ m s}^{-1}.$$

Final velocity

$$v = 0 \text{ m s}^{-1}$$

(since it is brought to rest).

Acceleration

$$a = -0.5 \text{ m s}^{-2}.$$

Using the third equation

$$v^2 = u^2 + 2as:$$

$$0 = (25)^2 + 2(-0.5)s$$

$$0 = 625 - 1s$$

$$s = 625 \text{ m.}$$

The car travels 625 m before fully stopping.

- 129.** (a) What physical quantities are obtained from the slope and the area under a velocity-time graph?
- (b) How does the velocity-time graph for constant velocity differ from one showing constant acceleration starting from rest?
- (c) A motorboat starting from rest accelerates at 3.0 m s^{-2} for 8.0 s . Calculate its displacement?

Ans :

- (a) From a velocity-time graph, the slope of the line gives the object's average acceleration, indicating exactly how fast velocity changes with time. The area enclosed between the velocity-time graph line and the time axis represents the total displacement of the object over that specific time interval.
- (b) A velocity-time graph representing constant velocity is a straight horizontal line parallel to the time axis, meaning the acceleration is zero. For constant acceleration starting from rest, the graph is a straight inclined line originating precisely from the origin, indicating a uniform increase in velocity.
- (c) For the accelerating motorboat:

$$\text{Initial velocity } u = 0 \text{ m s}^{-1}$$

$$\text{Acceleration } a = 3.0 \text{ m s}^{-2}$$

$$\text{Time } t = 8.0 \text{ s.}$$

Displacement 's' is calculated using the equation

$$s = ut + \frac{1}{2} at^2$$

$$s = (0 \times 8.0) + (0.5 \times 3.0 \times (8.0)^2)$$

$$s = 0 + (1.5 \times 64)$$

$$s = 96 \text{ m.}$$

The motorboat travels 96 metres.

130. (a) Explain the concept of braking distance for a moving vehicle?
- (b) Why does a vehicle travelling at a higher initial velocity require a much longer distance to stop?
- (c) A driver travelling at 54 km h^{-1} spots a hazard. His reaction time is 0.5 s , after which brakes cause an acceleration of -5 m s^{-2} . Find the total stopping distance?

Ans :

- (a) Braking distance is the physical distance a vehicle travels from the precise moment the brakes are applied until it completely stops.
- (b) Using the kinematic equation

$$v^2 = u^2 + 2as$$

when final velocity $v = 0$,

the distance is $s = -u^2/(2a)$

This clearly shows that stopping distance is directly proportional to the square of the initial velocity (u^2). Therefore, a faster vehicle needs a significantly longer distance to stop safely.

- (c) For the driver:

Initial speed

$$\begin{aligned} u &= 54 \text{ km h}^{-1} \\ &= 54 \times (5/18) \\ &= 15 \text{ m s}^{-1} \end{aligned}$$

During the 0.5 s reaction time, the car moves uniformly:

Reaction distance

$$\begin{aligned} &= u \times t \\ &= 15 \times 0.5 \\ &= 7.5 \text{ m.} \end{aligned}$$

Once brakes are applied ($a = -5 \text{ m s}^{-2}$):

$$\begin{aligned} 0^2 &= (15)^2 + 2(-5)s \\ 0 &= 225 - 10s \end{aligned}$$

$$s = 22.5 \text{ m (braking distance).}$$

Total stopping distance

$$\begin{aligned} &= \text{Reaction distance} + \text{Braking distance} \\ &= 7.5 + 22.5 = 30 \text{ m.} \end{aligned}$$

131. (a) Distinguish between average speed and average velocity?
- (b) Can an object have a zero average velocity but a non-zero average speed?

- (c) Usha swims in a 90 m long pool. She covers 180 m in one minute by swimming from one end to the other and back along the same path. Find her average speed and average velocity?

Ans :

- (a) Average speed is a scalar quantity defined as the total distance travelled divided by the total time taken. It has only magnitude. Average velocity is a vector quantity defined as the total net displacement divided by the total time. It involves both magnitude and direction.
- (b) Yes, an object can have zero average velocity and non-zero average speed. This occurs whenever an object returns exactly to its initial starting point. In this case, the total displacement becomes zero, making velocity zero, while the physical distance covered remains positive.
- (c) For Usha's swim:

$$\begin{aligned} \text{Total distance covered in one minute} \\ &= 90 \text{ m (forward)} + 90 \text{ m (return)} \\ &= 180 \text{ m.} \end{aligned}$$

Total displacement = 0 m (since she returns precisely to the starting end).

$$\text{Total time } t = 1 \text{ min} = 60 \text{ s.}$$

$$\begin{aligned} \text{Average speed} &= \text{Total distance/time} \\ &= 180 \text{ m}/60 \text{ s} \\ &= 3 \text{ m s}^{-1} \end{aligned}$$

$$\begin{aligned} \text{Average velocity} &= \text{Displacement/time} \\ &= 0 \text{ m}/60 \text{ s} \\ &= 0 \text{ m s}^{-1} \end{aligned}$$

NUMERICAL QUESTIONS

132. A racing car has a uniform acceleration of 4 m s^{-2} . What distance will it cover in 10 s after start?

Ans :

Given: Uniform acceleration $a = 4 \text{ m s}^{-2}$.

Time $t = 10 \text{ s}$.

The car starts from rest, so initial velocity $u = 0 \text{ m s}^{-1}$.

We need to find the distance covered, (s).

Using the second equation of motion:

$$s = ut + \frac{1}{2}at^2$$

$$s = (0\text{ms}^{-1})(10\text{s}) + \frac{1}{2}(4\text{ms}^{-2})(10\text{s})^2$$

$$s = 0 + \frac{1}{2} \times 4 \times 100\text{m}$$

The racing car will cover 200 meters in 10 seconds after starting.

- 133.** Usha swims in a 90 m long pool. She covers 180 m in one minute by swimming from one end to the other and back along the same straight path. Find her average speed and average velocity.

Ans :

Total distance covered by Usha = 180 m.

Total time taken = 1 minute = 60 s.

Average speed

$$= \frac{\text{Total distance covered}}{\text{Total time taken}} = \frac{180\text{m}}{60\text{s}} = 3\text{ms}^{-1}$$

Since Usha swims from one end to the other and back to her starting point along the same straight path, her initial and final positions are the same. Therefore, her total displacement = 0 m.

Average velocity

$$= \frac{\text{Total displacement}}{\text{Total time taken}} = \frac{0\text{m}}{60\text{s}} = 0\text{ms}^{-1}$$

So, Usha's average speed is 3 m/s^{-1} , and her average velocity is 0 m/s^{-1} .

- 134.** During an experiment, a signal from a spaceship reached the ground station in five minutes. What was the distance of the spaceship from the ground station? The signal travels at the speed of light, that is

Ans :

Time taken for the signal to reach = 5 minutes.

Converting time to seconds:

$$t = 5 \text{ minutes} \times 60 \text{ seconds/minute} = 300\text{s}.$$

Speed of the signal (speed of light) $v = 3 \times 10^8 \text{ms}^{-1}$

Distance (s) can be calculated using the formula: distance = speed $\times$ time.

$$s = v \times t$$

$$s = (3 \times 10^8 \text{ms}^{-1}) \times (300\text{s})$$

$$s = 900 \times 10^8 \text{m}$$

$$s = 9 \times 10^{10} \text{m (or } 9 \times 10^7 \text{km)}.$$

The distance of the spaceship from the ground station was 9×10^{10} meters.

- 135.** An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 hours to revolve around the Earth.

Ans :

Given,

Radius of the circular orbit $r = 42250\text{km}$.

Time taken for one revolution $t = 24\text{hours}$.

The distance covered in one revolution is the circumference of the orbit, $C = 2\pi r$.

$$C = 2 \times \pi \times 42250 \text{ km}$$

Using $\pi \approx 3.14$

$$C \approx 2 \times 3.14 \times 42250 \text{ km}$$

$$\approx 265330 \text{ km}$$

$$\text{Speed (v)} = \frac{\text{Distance}}{\text{Time}} = \frac{C}{t}$$

$$v \approx \frac{265330 \text{ km}}{24 \text{ hours}}$$

$$\approx 11055.42 \text{ km/h}$$

To convert to m/s:

$$11055.42 \times \frac{1000\text{m}}{1\text{km}} \times \frac{1\text{h}}{3600\text{s}} \approx 3070.95 \text{ ms}$$

- 136.** A bus decreases its speed from 80 km h^{-1} to 60 km h^{-1} in 5 s. Find the acceleration of the bus.

Ans :

Initial speed $u = 80 \text{ kmh}^{-1}$.

Convert to m/s:

$$u = 80 \times \frac{1000\text{m}}{3600\text{s}}$$

$$= 80 \times \frac{5}{18} \text{ms}^{-1}$$

$$= \frac{400}{18} \text{ms}^{-1} \approx 22.22 \text{ms}^{-1}$$

Final speed $v = 60 \text{ kmh}^{-1}$

Convert to m/s:

$$v = 60 \times \frac{1000\text{m}}{3600\text{s}}$$

$$= 60 \times \frac{5}{18} \text{ms}^{-1}$$

$$= \frac{300}{18} \text{ms}^{-1} \approx 16.67 \text{ms}^{-1}$$

Time taken $t = 5 \text{ s}$.

$$\text{Acceleration } a = \frac{(v - u)}{t}$$

$$a = \frac{(16.67 \text{ms}^{-1} - 22.22 \text{ms}^{-1})}{5\text{s}}$$

$$= \frac{-5.55 \text{ms}^{-1}}{5\text{s}} = -1.11 \text{ms}^{-2}$$

The acceleration of the bus is approximately -1.11 m s^{-2} (the negative sign indicates retardation).

Time taken (B to C) = 1 minute = 60 s.

Total time (A to C) = 150s + 60s = 210s.

$$\begin{aligned}\text{Average speed (A to C)} &= \frac{\text{Total Distance}}{\text{Total Time}} \\ &= \frac{400\text{m}}{210\text{s}} \\ &= \frac{40}{21}\text{ms}^{-1} \approx 1.90\text{ms}^{-1}\end{aligned}$$

(d) Average velocity from A to C:

Displacement (A to C)

= Displacement (A to B)

– Displacement (C to B, since he turns back)

Displacement (A to C)

= 300 m (from A to B) – 100 m (from B to C towards A)

= 200 m

in the original direction of A to B.

Total time (A to C) = 210 s.

Average velocity (A to C)

$$= \frac{\text{Total Displacement}}{\text{Total Time}}$$

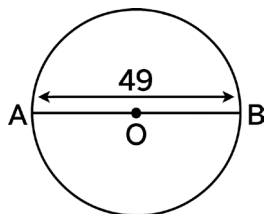
$$= \frac{200\text{m}}{210\text{s}}$$

$$= \frac{20}{21}\text{ms}^{-1} \approx 0.95\text{ms}^{-1}$$

in the direction from A to B.

- 161.** An athlete completes one round of a circular track of diameter 49 m in 20 s. Calculate the distance covered of displacement at end of 30 s.

Ans :



Here, diameter = 49 cm

As an athlete completes one round of a circular track in a period $T = 20$ s, hence in time $t = 30$ s, he will complete $n = \frac{30}{20} = 1.5$ rounds. Thus, he will beat point B diagonally opposite to initial position A

Displacement = AB = D = 49 m

Distance covered

$$\begin{aligned}n(2\pi r) &= n(\pi D) \\ &= 1.5 \times \frac{22}{7} \times 49 \\ &= 231\text{ m}\end{aligned}$$

- 162.** Abdul, while driving to school, computes the average speed for his trip to be 20 km h^{-1} . On his return trip along the same route, there is less traffic and the average speed is 30 km h^{-1} . What is the average speed for Abdul's entire trip?

Ans :

Let the distance from home to school be 'd' km.

Time taken to go to school

$$\begin{aligned}(t_1) &= \frac{\text{Distance}}{\text{Average speed}} \\ &= \frac{d}{20}\text{ hours.}\end{aligned}$$

Time taken for the return trip

$$\begin{aligned}(t_2) &= \frac{\text{Distance}}{\text{Average speed}} \\ &= \frac{d}{30}\text{ hours.}\end{aligned}$$

Total distance for the entire trip

$$\begin{aligned}&= d(\text{to school}) + d(\text{return}) \\ &= 2d\text{ km}\end{aligned}$$

Total time taken for the entire trip = $t_1 + t_2$

$$= \frac{d}{20} + \frac{d}{30}\text{ hours.}$$

To add the times, find a common denominator (e.g., 60):

$$\begin{aligned}\text{Total time} &= \frac{(3d + 2d)}{60} \\ &= \frac{5d}{60} \\ &= \frac{d}{12}\text{ hours.}\end{aligned}$$

Average speed for Abdul's entire trip

$$\begin{aligned}&= \frac{\text{Total distance}}{\text{Total time}} \\ &= \frac{2d\text{km}}{(d/12)\text{ hours}} \\ &= 2d \times \frac{12}{d}\text{ km/h} \\ &= 2 \times 12\text{km/h} \\ &= 24\text{km/h.}\end{aligned}$$

The average speed for Abdul's entire trip is 24 km h^{-1} .

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- 163.** A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0 m s^{-2} for 8.0 s. How far does the boat travel during this time?

ABCD, its value is

$$\begin{aligned} ABCD &= AB \times BC \quad (30 \text{ min} - 10 \text{ min}) \\ &\quad \times (10 \text{ km/h}) \\ &= 20 \text{ min} \times 10 \text{ km/h} \\ &= \frac{20}{60} \text{ h} \times 10 \text{ km/h} = \frac{10}{3} \text{ km} \end{aligned}$$

- 141.** A train starting from a railway station and moving with uniform acceleration, attains a speed 40 km/h in 10 minutes. Find its acceleration.

Ans :

Given,

Initial velocity $u = 0$ (starting from rest)

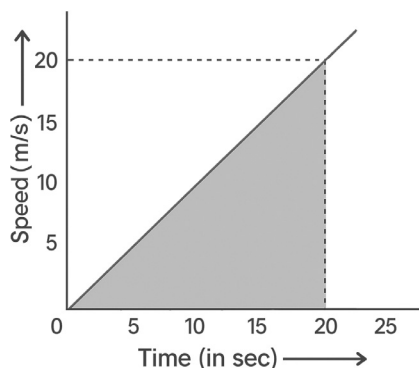
Final velocity $v = 40 \text{ km/h}$
 $= \frac{40 \times 5}{18} = 11.11 \text{ m/s}$

Time $t = 10 \text{ minutes}$
 $= 10 \times 60 = 600 \text{ s}$

We know that,

$$\begin{aligned} \text{Acceleration (a)} &= \frac{v - u}{t} \\ a &= \frac{11.11 \text{ m/s}}{600 \text{ s}} = 0.0185 \text{ m/s}^2 \end{aligned}$$

- 142.** Find the distance covered by a particle during the time interval $t = 0$ to $t = 20 \text{ s}$ for which the speed-time graph is shown in figure.



Ans :

The distance covered in the time interval 0 to 20 s is equal to the area of the shaded triangle. So,

$$\begin{aligned} \text{Distance} &= \frac{1}{2} \times \text{base} \times \text{height} \\ &= \frac{1}{2} \times (20 \text{ s}) \times (20 \text{ m/s}) \\ &= 200 \text{ m.} \end{aligned}$$

- 143.** The average speed of a bicycle, an athlete and car are 18 km/h, 7 m/s and 2 km/min respectively. Which of the three is the fastest and which is the slowest?

Ans :

$$18 \text{ km/h} = \frac{18 \text{ km}}{1 \text{ h}} = \frac{18000 \text{ m}}{3600 \text{ s}} = 5 \text{ m/s}$$

$$2 \text{ km/min} = \frac{2 \text{ km}}{1 \text{ min}} = \frac{2000 \text{ m}}{60 \text{ s}} = 33.3 \text{ m/s}$$

Thus, the average speeds of the bicycle, the athlete and the car are 5 m/s, 7 m/s and 33.3 m/s respectively. So, the car is the fastest and the bicycle is the slowest.

- 144.** A bus moves 30 km in 30 min and the next 30 km. in 40 min. Calculate the average speed for the entire journey.

Ans :

Given, the total time taken is 30 min + 40 min = 70 min

and the total distance travelled is 30 km + 30 km = 60 km

The average speed is

$$\begin{aligned} V_{av} &= \frac{60 \text{ km}}{70 \text{ min}} = \frac{60 \text{ km}}{(70/60) \text{ h}} \\ &= \frac{3600}{70} \text{ km/hr} \\ &= 51.4 \text{ km/h} \end{aligned}$$

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- 145.** A girl runs for 10 min at a uniform speed of 9 km/h. What should be the speed that she runs for the next 20 min, so that the average speed comes to 12 km/h?

Ans :

Given, Total time = 10 min + 20 min = 30 min

The average speed is 12 km/h using $s = vt$, the distance covered in 30 min is

$$12 \text{ km/h} \times 30 \text{ min} = \frac{12 \text{ km}}{\text{h}} \times \frac{1}{2} \text{ h} = 6 \text{ km}$$

The distance covered in the first 10 min is :

$$9 \text{ km/h} \times 10 \text{ min} = \frac{9 \text{ km}}{\text{h}} \times \frac{1}{6} \text{ h} = 1.5 \text{ km}$$

Thus, he has to cover $6 \text{ km} - 1.5 \text{ km} = 4.5 \text{ km}$ in the next 20 min.

The speed required is

$$\frac{4.5 \text{ km}}{20 \text{ min}} = \frac{4.5 \text{ km}}{(20/60) \text{ h}} = 13.5 \text{ km/h}$$

- 146.** It is estimated that the radio signal takes 1.27 seconds to reach the Earth from the surface of the Moon. Calculate the distance of the Moon from the Earth. Speed of radio signal = $3 \times 10^8 \text{ ms}^{-1}$ (speed of light in air).

Ans :

Given, time = 1.27 s

$$\text{Speed} = 3 \times 10^8 \text{ ms}^{-1}$$

Distance = ?

As we know that

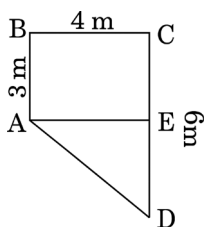
Using distance = speed $\times$ time, we get

$$\begin{aligned} \text{Distance} &= 3 \times 10^8 \text{ ms}^{-1} \times 1.27 \text{ s} \\ &= 3.81 \times 10^8 \text{ m} \\ &= 3.81 \times 10^5 \text{ km} \end{aligned}$$

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- 147.** A particle moves 3 m north, then 4 m east and finally 6 m south. Calculate the magnitude of displacement.

Ans :



As shown in figure let us consider east-west direction along x-axis and north-south direction along y-axis. Then AB, BC and CD represent the displacement of 3 m north, 4 m east and 6 m south respectively.

Obviously net displacement is represented by AD magnitude of net displacement

$$\begin{aligned} s &= AD \\ &= \sqrt{(AE)^2 + (ED)^2} \\ &= \sqrt{(BC)^2 + (CD - AB)^2} \\ &= \sqrt{(4)^2 + (6 - 3)^2} \\ &= \sqrt{(4)^2 + (3)^2} \\ &= \sqrt{16 + 9} = \sqrt{25} = 5 \text{ m} \end{aligned}$$

- 148.** An electric train is moving with a velocity of 120 km/h. How much distance will it cover in 30 s?

Ans :

Constant velocity of train

$$v = 120 \text{ km/h}$$

$$\begin{aligned} 120 \times \frac{5}{18} &= \frac{100}{3} \text{ m/s, time } t \\ &= 30 \text{ s} \end{aligned}$$

Distance covered

$$\begin{aligned} s &= vt \\ &= \frac{100}{3} \times 30 \\ &= 1000 = 1.0 \text{ km.} \end{aligned}$$

- 149.** On a 120 km track, a train travels the first 30 km at uniform speed of 30 km/h. Calculate the speed with which the train should move rest of the track so as to get the average speed of 60 km/h for entire trip.

Ans :

As the average speed of a train for entire journey

$$s = 120 \text{ km is } v_{av} = 60 \text{ km/h}$$

Hence, total time taken by train to cover the journey

$$t = \frac{s}{v_{av}} = \frac{120 \text{ km}}{60 \text{ km/h}} = 2 \text{ h}$$

Time taken to travel first 30 km at uniform speed of 30 km/h

$$t_1 = \frac{30 \text{ km}}{30 \text{ km/h}} = 1 \text{ hr}$$

Time for covering remaining distance [120 – 30] = 90 km should be

$$\begin{aligned} t_2 &= t - t_1 \\ &= (2 - 1) \text{ h} = 1 \text{ h} \end{aligned}$$

Constant speed of train for this journey

$$\begin{aligned} v_2 &= \frac{s_2}{t_2} = \frac{90 \text{ km}}{1 \text{ h}} \\ &= 90 \text{ km/h} \end{aligned}$$

- 150.** A girl while riding a bicycle moves with the speed of 10 km/h for 2 hours and with the speed of 15 km/h in next 2 hours. Find the total distance moved by her and her average speed.

Ans :

Distance moved by girl in time

$$(t_1) = 2 \text{ h with a speed}$$

$V_1 = 10 \text{ km/h}$ is given as

$$s_1 = V_1 t_1 = 10 \times 2 = 20 \text{ km}$$

and distance moved by girl in subsequent time

$$t_2 = 3 \text{ h with speed } V_2 = 15 \text{ km/h}$$

is given as :

$$s_2 = V_2 t_2 = 15 \times 3 = 45 \text{ km}$$

Total distance moved by girl = $20 + 45 = 65$

Her average speed for entire journey V_{av}

$$= \frac{\text{Total distance}}{\text{Total time}} = \frac{s}{t_1 + t_2}$$

$$= \frac{65}{5} = 13 \text{ km/h}$$

- 151.** A marble rolling on the smooth has a initial velocity of 0.4 m/s . If the floor offers a retardation of 0.02 m/s , calculate the time it will take to come to rest.

Ans :

Here initial velocity

$$u = 0.4 \text{ m/s}$$

final velocity $v = 0$

acceleration $a = -0.02 \text{ m/s}$

As per relation $v = u + at$

$$t = \frac{v - u}{a} = \frac{0 - 0.4}{-0.02}$$

$$= \frac{-0.4}{-0.02}$$

$$= 20 \text{ s}$$

- 152.** A cyclist completes 8 revolutions of a circular track of radius 98 m with a uniform speed in 40 minutes. Calculate the speed.

Ans :

Here no. of revolutions completed by the cyclist

$n = 8$, radius of circular track

$$r = 98$$

and time, $t = 40 \text{ min}$

$$= 40 \times 60 \text{ s}$$

$$= 2400 \text{ s}$$

Uniform speed of cyclist

$$v = \frac{\text{Total distance}}{\text{Total time}} = \frac{2\pi r n}{t}$$

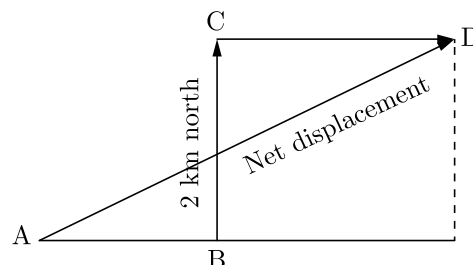
$$= \frac{2 \times \frac{22}{7} \times 98 \times 8}{2400}$$

$$= 0.05 \text{ m/s}$$

- 153.** A person moves a distance of 3 km towards east then 2 km towards north and then 3.5 km towards east. Find :

- (a) The distance covered by the person, and
(b) the displacement of his motion.

Ans :



As shown AB, BC and CD represent the distance of 3 km east, 2 km north and 3.5 km east respectively.

- (a) Net distance covered by a person

$$= AB + BC + CD$$

$$= (3 + 2 + 3.5) \text{ km} = 8.5 \text{ km}$$

- (b) Net displacement

$$\begin{aligned} AD &= \sqrt{(AE)^2 + (ED)^2} \\ &= \sqrt{(AB + CD)^2 + (BC)^2} \\ &= \sqrt{(3 + 3.5)^2 + (2)^2} \\ &= \sqrt{(6.5)^2 + (2)^2} \\ &= \sqrt{42.25 + 4} \\ &= \sqrt{46.25} \\ &= 6.8 \text{ km} \end{aligned}$$

- 154.** Divya walked 2 km on a straight road and then walked back 1 km . Which of the two quantities involved in her walking is greater- the scalar or vector?

Ans :

Distance travelled by Divya

$$= 2 \text{ km} + 1 \text{ km} = 3 \text{ km}$$

$$\text{Displacement} = 2 \text{ km} - 1 \text{ km} = 1 \text{ km}$$

Hence, distance which is a scalar quantity is greater than the displacement which is a vector quantity.

- 155.** A child moving on a circular track of radius 40 m completes one revolution in 5 minutes. What is his (i) average speed (ii) average velocity in one full revolution?

- 137.** A person moves along the boundary of a square field of side 10 m in 20 s. What will be the magnitude of displacement of that person at the end of 2 minutes 20 seconds?

Ans :

Given, Side of square field = 10 m

So, perimeter = $10 \text{ m} \times 4$
 $= 40 \text{ m}$

Person moves along the boundary in 20 sec.

Displacement after 2 m 20 sec

$$= 2 \times 60 \text{ s} + 20 \text{ s}$$

$$= 140 \text{ s} = ?$$

Since in 20 sec person moves 40 m.

Therefore, in 1 sec distance covered

$$= \frac{40}{20} = 2 \text{ m}$$

Therefore, in 140 sec distance covered

$$= 2 \times 140$$

$$= 280 \text{ m}$$

Now, number of rotation to cover 240 along the boundary

$$= \frac{\text{Total distance}}{\text{Perimeter}}$$

$$= \frac{280 \text{ m}}{40 \text{ m}}$$

$$= 7 \text{ rounds.}$$

Hence, after 7 rounds the person will be at the starting point, so displacement will be zero.

- 138.** Neha swims in a 90 m long pool. She covers 180 m in one minute by swimming from one end to the other and back along the same straight path. Find the average speed and average velocity of Neha.

Ans :

Given, Total distance = 180 m

Total displacement = 0

Time taken $t = 1 \text{ min} = 60 \text{ s}$

We know that,

$$\text{Average speed } (V_{av}) = \frac{\text{Total distance}}{\text{Total time taken}}$$

$$= \frac{180 \text{ m}}{60 \text{ s}} = 3 \text{ m/s}$$

$$\text{Average velocity } (V_{av}) = \frac{\text{Displacement}}{\text{Total time taken}}$$

$$= \frac{0}{60 \text{ s}} = 0 \text{ m/s}$$

- 139.** A car decreases its speed from 80 km/h to 60 km/h in 5 seconds. Find the acceleration of the car.

Ans :

Given,

$$\text{Initial velocity } u = 80 \text{ km/h} = 80 \times \frac{5}{18} \\ = 22.22 \text{ m/s}$$

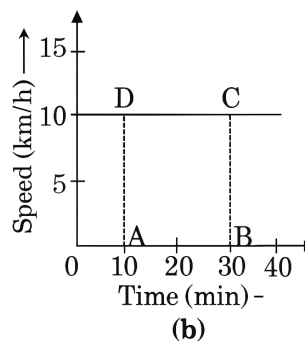
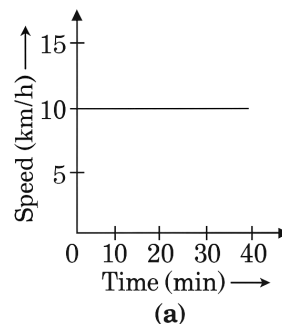
$$\text{Final velocity } v = 60 \text{ km/h} = 60 \times \frac{5}{18} \\ = 16.67 \text{ m/s}$$

We know that,

$$\text{Time } (t) = 5 \text{ s}$$

$$\text{Acceleration } (a) = \frac{v - u}{t} \\ = \frac{(16.67 - 22.22) \text{ m/s}}{5 \text{ s}} \\ = -1.11 \text{ m/s}^2$$

- 140.** Figure represents the speed time graph for a particle. Find the distance covered by the particle between $t = 10 \text{ min}$ and $t = 30 \text{ min}$.



Ans :

We draw perpendicular lines from the 10-minute point and the 30-minute point to the time-axis (fig.). The distance covered is equal to the area of the rectangle

- 158.** The brakes applied to a car produce an acceleration of 6 m s^{-2} in the opposite direction to the motion. If the car takes 2 s to stop after the application of brakes, calculate the distance it travels during this time.

Ans :

Given: Acceleration (retardation) $a = -6 \text{ ms}^{-2}$
(negative as it's opposite to motion).

Time taken to stop $t = 2 \text{ s}$.

Final velocity $v = 0 \text{ ms}^{-1}$ (since the car stops).

Using the first equation of motion,

$$v = u + at$$

$$0 = u + (-6 \text{ ms}^{-2})(2 \text{ s})$$

$$0 = u - 12 \text{ ms}^{-1}$$

So, initial velocity

$$u = 12 \text{ ms}^{-1}.$$

Now, using the second equation of motion

$$s = ut + \frac{1}{2}at^2$$

$$= (12 \text{ ms}^{-1})(2 \text{ s}) + \frac{1}{2}(-6 \text{ ms}^{-2})(2 \text{ s})^2$$

$$= 24 \text{ m} - 12 \text{ m} = 12 \text{ m}.$$

The car travels 12 m during this time.

- 159.** A train starting from rest attains a velocity of 72 km h^{-1} in 5 minutes . Assuming the acceleration is uniform, find (i) the acceleration and (ii) the distance travelled by the train for attaining this velocity.

Ans :

Initial velocity $u = 0$ (starts from rest).

Final velocity

$$v = 72 \text{ kmh}^{-1}$$

$$= 72 \times \frac{1000 \text{ m}}{3600 \text{ s}} = 20 \text{ ms}^{-1}$$

Time $t = 5 \text{ min}$

$$= 5 \times 60 \text{ s} = 300 \text{ s}$$

- (i) Acceleration (a):

Using $v = u + at$

$$a = \frac{(v - u)}{t}$$

$$= \frac{(20 \text{ ms}^{-1} - 0)}{300 \text{ s}}$$

$$= \frac{20}{300} \text{ ms}^{-2}$$

$$= \frac{1}{15} \text{ ms}^{-2} \approx 0.067 \text{ ms}^{-2}$$

- (ii) Distance travelled (s):

Using $2as = v^2 - u^2$

$$s = \frac{(v^2 - u^2)}{2a}$$

$$= \frac{((20 \text{ ms}^{-1})^2 - 0^2)}{(2 \times \frac{1}{15} \text{ ms}^{-2})}$$

$$= \frac{400}{(2/15)} \text{ m}$$

$$= 400 \times \frac{15}{2} \text{ m}$$

$$= 3000 \text{ m} = 3 \text{ km}$$

- 160.** Joseph jogs from one end A to the other end B of a straight 300 m road in $2 \text{ minutes } 30 \text{ seconds}$ and then turns around and jogs 100 m back to point C in another 1 minute .

- (a) What is Joseph's average speed from A to B?
(b) What is Joseph's average velocity from A to B?
(c) What is Joseph's average speed from A to C?
(d) What is Joseph's average velocity from A to C?

Ans :

- (a) Average speed from A to B:

Distance (A to B) = 300 m .

Time taken (A to B) = $2 \text{ minutes } 30 \text{ seconds}$

$$= (2 \times 60) + 30 = 150 \text{ s}$$

Average speed (A to B) = $\frac{\text{Distance}}{\text{Time}}$

$$= \frac{300 \text{ m}}{150 \text{ s}} = 2 \text{ ms}^{-1}$$

- (b) Average velocity from A to B:

Displacement (A to B) = 300 m (since it's a straight road in one direction).

Time taken (A to B) = 150 s .

Average velocity (A to B) = $\frac{\text{Displacement}}{\text{Time}}$

$$= \frac{300 \text{ m}}{150 \text{ s}} = 2 \text{ ms}^{-1}$$

in the direction from A to B.

- (c) Average speed from A to C:

Distance (A to B) = 300 m .

Distance (B to C) = 100 m .

Total distance (A to C)

$$= 300 \text{ m} + 100 \text{ m} = 400 \text{ m}$$

Time taken (A to B) = 150 s .

Ans :

Distance travelled in one revolution,

$$2\pi r = 2\pi \times 40\text{m}$$

Displacement in one revolution = 0

$$\text{Time taken} = 5 \text{ minutes} = 5 \times 60\text{s}$$

$$\begin{aligned} \text{(i) Average speed} &= \frac{\text{Distance}}{\text{Time}} = \frac{2\pi \times 40}{5 \times 60} \\ &= \frac{4\pi}{15} \text{ m/s} \end{aligned}$$

$$\text{(ii) Average velocity} = \frac{\text{Displacement}}{\text{Time}} = \text{Zero}$$

- 156.** An athlete completes one round of a circular track of diameter 200 m in 40 s.

- (a) What is the distance covered by the athlete in 2 minutes 20 s?
 (b) What is the magnitude of the displacement of the athlete at the end of 2 minutes 20 s?

Ans :

Diameter of the circular track = 200 m.

$$\begin{aligned} \text{Radius } r &= \frac{\text{diameter}}{2} \\ &= \frac{200\text{m}}{2} = 100\text{m} \end{aligned}$$

Time taken for one round = 40 s.

Distance covered in one round (circumference)

$$\begin{aligned} C &= 2\pi r \\ &= 2 \times \pi \times 100\text{m} = 200\pi\text{m} \end{aligned}$$

Let's use $\pi \approx \frac{22}{7}$

$$\begin{aligned} C &= 200 \times \frac{22}{7} \\ &= \frac{4400}{7}\text{m} \approx 628.57 \text{ m} \end{aligned}$$

Total time of motion = 2 minutes 20 s

$$= (2 \times 60)\text{s} + 20\text{s}$$

$$= 120\text{s} + 20\text{s} = 140\text{s}$$

Number of rounds completed

$$\begin{aligned} &= \frac{\text{Total time}}{\text{Time for one round}} \\ &= \frac{140\text{s}}{40\text{s}} = 3.5\text{rounds} \end{aligned}$$

- (a) Distance covered:

Distance = Number of rounds $\times$ Circumference

$$\text{Distance} = 3.5 \times 200\pi\text{m} = 700\pi\text{m}$$

Using $\pi \approx \frac{22}{7}$:

$$\begin{aligned} \text{Distance} &= 700 \times \frac{22}{7} \text{ m} \\ &= 100 \times 22 \text{ m} = 2200 \text{ m} \end{aligned}$$

- (b) Magnitude of displacement: After 3 complete rounds, the athlete is back at the starting point, so displacement is zero for these 3 rounds.

For the remaining 0.5 round (half a circle), the athlete moves from the starting point to a point diametrically opposite on the circular track.

The shortest distance between these two points is the diameter of the circle.

Magnitude of displacement

$$= \text{Diameter} = 200 \text{ m.}$$

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- 157.** A farmer moves along the boundary of a square field of side 10 m in 40 s. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds from his initial position?

Ans :

Side of square field = 10 m.

$$\text{Perimeter} = 4 \times 10 = 40\text{m.}$$

Time taken for one round = 40 s.

$$\text{Total time} = 2 \text{ minutes } 20 \text{ seconds}$$

$$= (2 \times 60) + 20$$

$$= 120 + 20 = 140\text{s.}$$

Number of rounds completed

$$\begin{aligned} &= \frac{\text{Total time}}{\text{Time for one round}} \\ &= \frac{140\text{s}}{40\text{s}} = 3.5 \text{ rounds} \end{aligned}$$

After 3 complete rounds, the farmer is at the starting point. After the next 0.5 round (half perimeter = 20 m), the farmer will be at the diagonally opposite corner.

If the starting point is A, the diagonally opposite corner is C.

$$\begin{aligned} \text{Displacement} &= AC = \sqrt{(AB^2 + BC^2)} \\ &= \sqrt{(10^2 + 10^2)} \\ &= \sqrt{(100 + 100)} \\ &= \sqrt{200} \\ &= 10\sqrt{2} \text{ m} \approx 14.14\text{m} \end{aligned}$$

Ans :

Given:

Initial velocity $u = 0 \text{ m s}^{-1}$ (starts from rest).

Constant acceleration $a = 3.0 \text{ m s}^{-2}$.

Time $t = 8.0 \text{ s}$.

We need to find the distance travelled, s .

Using the second equation of motion: $s = ut + \frac{1}{2}at^2$

$$s = (0 \text{ m s}^{-1})(8.0 \text{ s}) + \frac{1}{2}(3.0 \text{ m s}^{-2})(8.0 \text{ s})^2$$

$$= 0 + \frac{1}{2} \times 3.0 \times (64) \text{ m}$$

$$= \frac{1}{2} \times 3.0 \times 64 \text{ m}$$

$$= 1.5 \times 64 \text{ m}$$

$$= 96.0 \text{ m}.$$

The boat travels 96.0 meters during this time.

- 164.** A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 m s^{-2} , with what velocity will it strike the ground? After what time will it strike the ground?

Ans :

Given:

Initial velocity $u = 0 \text{ m s}^{-1}$ (gently dropped means starts from rest).

Distance (height) $s = 20 \text{ m}$.

Uniform acceleration (due to gravity) $a = 10 \text{ m s}^{-2}$ (downwards, taken as positive).

Let 'v' be the final velocity when it strikes the ground, and 't' be the time taken.

To find the final velocity (v):

Using the third equation of motion:

$$v^2 = u^2 + 2as.$$

$$v^2 = (0)^2 + 2(10 \text{ m s}^{-2})(20 \text{ m})$$

$$= 0 + 400 \text{ m}^2 \text{ s}^{-2}$$

$$= 400 \text{ m}^2 \text{ s}^{-2}$$

$$v = \sqrt{400} \text{ m s}^{-1}$$

$$= 20 \text{ m s}^{-1}$$

The ball will strike the ground with a velocity of 20 m/s .

To find the time taken (t):

Using the first equation of motion:

$$v = u + at.$$

$$20 \text{ m s}^{-1} = 0 \text{ m s}^{-1} + (10 \text{ m s}^{-2}) t$$

$$t = \frac{20}{10} \text{ s} = 2 \text{ s}$$

The ball will strike the ground after 2 seconds.

- 165.** An athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 minutes 20 s?

Ans :

Given, Diameter of circular track (D) = 200 m

Radius of circular track (r) = $\frac{200}{2} = 100 \text{ m}$

Time taken by the athlete for one round (t) = 40 s

Distance covered by athlete in one round

$$s = 2\pi r = 2 \times \frac{22}{7} \times 100$$

Speed of the athlete

$$v = \frac{\text{Distance}}{\text{Time}} = \frac{2 \times 2200}{7 \times 40}$$

$$= \frac{4400}{7 \times 40}$$

Therefore, distance covered in 140 s

$$= \text{Speed (s)} \times \text{Time (t)}$$

$$= \frac{4400}{7 \times 40} \times (2 \times 60 + 20)$$

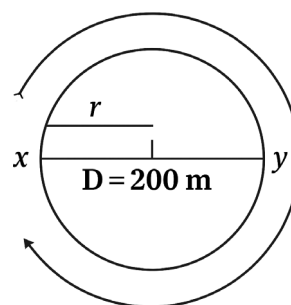
$$= \frac{4400}{7 \times 40} \times 140$$

$$= \frac{4400 \times 140}{7 \times 40} = 2200 \text{ m}$$

Number of round in 40 s = 1 round

Number of round in 140 s = $\frac{140}{40} = 3\frac{1}{2}$

After taking start from position X, the athlete will be at position Y after $3\frac{1}{2}$ rounds as shown in figure



Hence, displacement of the athlete with respect to initial position at x = xy

$$= \text{Diameter of circular track}$$

$$= 200 \text{ m}$$

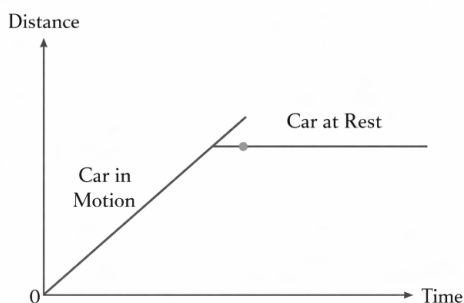
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(d) Using $s = ut + \frac{1}{2}at^2$
 $s = 0(30) + \frac{1}{2} \times 2 \times (30)^2$
 $s = 0 + 1\ 900$

The distance travelled is 900 meters.

- (e) If the acceleration is lower, the cargo plane will take more time to reach the required 60 m/s takeoff velocity. Consequently, it will cover a greater distance before lifting off, requiring a longer runway.

184. The distance-time graph for a car's motion is a straight line sloping upwards, passing through the origin. After some time, the graph becomes a horizontal straight line parallel to the time axis.



1. What does the straight line sloping upwards from the origin indicate about the car's motion?
2. What does the horizontal straight line (parallel to the time axis) indicate about the car's motion during that period?
3. How can you determine the speed of the car from the first part of the graph (sloping upwards)?
4. If the initial upward sloping line was steeper, what would it imply about the car's speed?

Ans :

1. A straight line sloping upwards from the origin on a distance-time graph indicates that the car is moving with uniform speed (or uniform velocity if direction is constant).
2. A horizontal straight line parallel to the time axis on a distance-time graph indicates that the car is at rest (its distance from the origin is not changing with time).
3. The speed of the car can be determined by calculating the slope of the distance-time graph (change in distance / change in time).

4. If the initial upward sloping line was steeper, it would imply that the car's speed is greater (it covers more distance in the same amount of time, or the same distance in less time).

185. During a road safety awareness campaign at a local high school, a police inspector demonstrates the concept of braking distance using a computer simulation. The simulation shows a car travelling at 20 meters per second on a dry highway. The virtual driver suddenly sees a fallen tree ahead and slams on the brakes. The car's braking system provides a constant negative acceleration of -5 meters per second squared. The inspector explains that avoiding an accident depends not just on the brakes, but also on the driver's reaction time and road conditions like rain, which can heavily reduce tire friction and change the deceleration capacity.

QUESTIONS:

- (a) Calculate the time it takes for the simulated car to come to a complete stop after the brakes are applied.
- (b) How much distance does the car travel from the moment the brakes are applied until it stops completely?
- (c) If the driver had a slower reaction time and delayed applying the brakes by 1 second, what additional distance would the car travel at its initial speed?
- (d) According to the inspector's explanation, how would a wet road affect the car's stopping distance?

Ans :

- (a) Initial velocity (u) = 20 m/s
 final velocity (v) = 0 m/s
 acceleration (a) = -5 m/s²
 Using $v = u + at$
 $0 = 20 + (-5)t$
 $5t = 20$
 so time (t) = 4 seconds
- (b) Using $v^2 = u^2 + 2as$
 $0^2 = 20^2 + 2(-5)s$
 $0 = 400 - 10s$
 $10s = 400$
 Distance (s) = 40 meters.

- 169.** A driver of a car travelling at 52 km h^{-1} applies the brakes and accelerates uniformly in the opposite direction. The car stops in 5 s. Another driver going at 3 km h^{-1} in another car applies his brakes slowly and stops in 10 s. On the same graph paper, plot the speed versus time graphs for the two cars. Which of the two cars travelled farther after the brakes were applied?

Ans :

PR and SQ are the speed-time graph for given two cars with initial speeds 52 km h^{-1} and 3 km h^{-1} respectively (given in figure).

Initial speed of car A = 52 km h^{-1}

$$= 52 \times \frac{5}{18}$$

$$= 14.44 \text{ ms}^{-1}$$

The car stops in 5 s i.e., final speed of car $v = 0$, time $t = 5 \text{ s}$ For speed-time graph of car A.

s	14.44 ms^{-1}	0
t	0	5

Initial speed of car B = 3 km h^{-1}

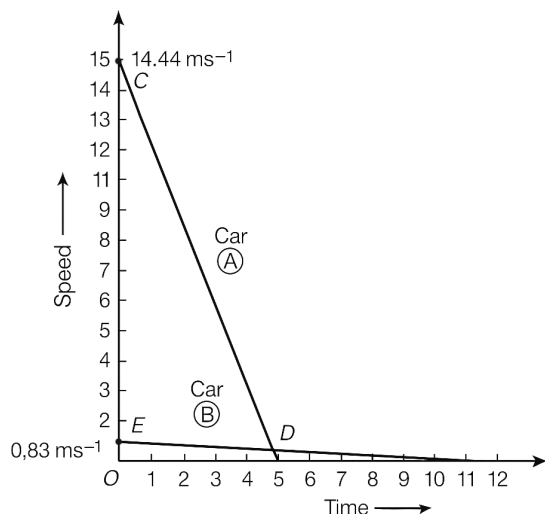
$$= 3 \times \frac{5}{18} = 0.83 \text{ ms}^{-1}$$

The car stops in 10 s i.e., final speed of car $v = 0$, time $t = 10 \text{ s}$. for speed-time graph of car B

s	0.83 ms^{-1}	0
t	0	10

Motion

The speed-time graph of both cars A and B is shown below.



- 170.** A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 m s^{-2} , with what velocity will it strike the ground? After what time will it strike the ground?

Ans :

Let us assume, the final velocity with which ball will strike the ground be v and time it takes to strike the ground be t .

Initial velocity of ball, $u = 0$

Distance or height of fall, $s = 20 \text{ m}$

Downward acceleration, $a = 10 \text{ m s}^{-2}$

As we know that,

$$2as = v^2 - u^2$$

$$v^2 = 2as + u^2$$

$$= 2 \times 10 \times 20 + 0$$

$$= 400$$

Final velocity of ball,

$$v = 20 \text{ ms}^{-1}$$

$$t = \frac{(v - u)}{a}$$

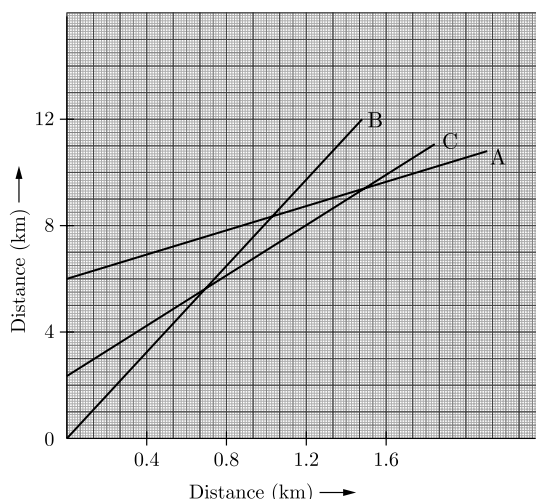
Time taken by the ball to strike

$$= \frac{(20 - 0)}{10}$$

$$= \frac{20}{10}$$

$$= 2 \text{ seconds}$$

- 171.** Figure shows the distance-time graph of three objects A, B and C. Study the graph and answer the following questions :



- Which of the three is travelling the fastest?
- Are all three ever at the same point on the road?
- How far has C travelled when B passes A?
- How far has B travelled by the time it passes C?

Ans :

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

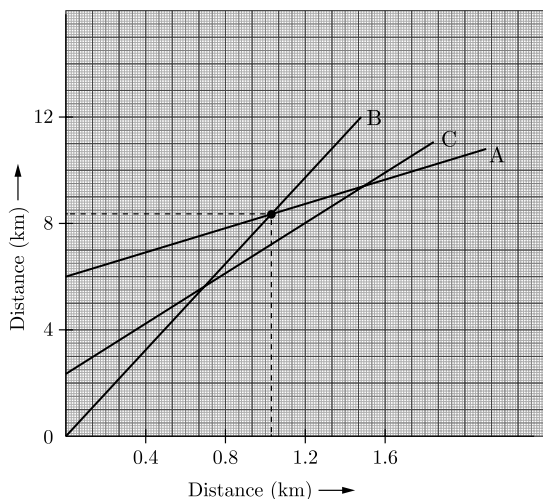
$$\text{Slope of graph} = \frac{\text{Y-axis}}{\text{X-axis}} = \frac{\text{Distance}}{\text{Time}}$$

Therefore, speed = slope of the graph

Since slope of object B is greater than objects A and C, it is travelling the fastest.

- All three objects A, B and C never meet at a single point. Thus, they were never at the same point on road.

(c)



7 square box = 4 km

1 square box = $\frac{4}{7}$ km

C is 4 blocks away from origin, therefore, initial distance of C from origin = $\frac{16}{7}$ km

Distance of C from origin when B passes A = 8 km

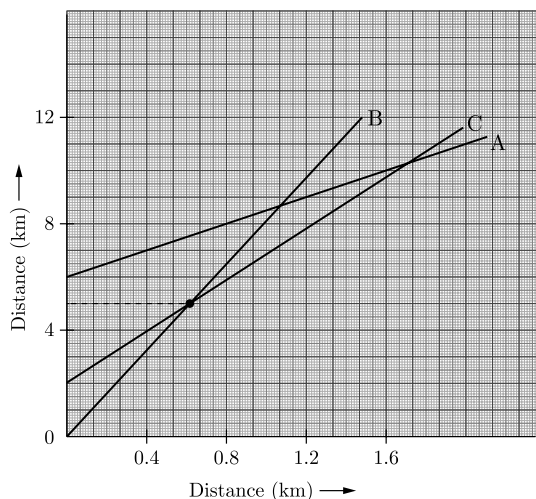
Thus, distance travelled by C when B passes A

$$= 8 - \frac{16}{7}$$

$$= \frac{(56 - 16)}{7}$$

$$= \frac{40}{7} = 5.714 \text{ km}$$

(d)



Distance travelled by B by the time it passes C = 9 square boxes

$$9 \times \frac{4}{7} = \frac{36}{7} = 5.143 \text{ km}$$

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CASE BASED QUESTIONS

- Rahul is travelling to his hometown on an express train. He calls his friend Amit, who is waiting for him at the destination station. Rahul says, "I am sitting on my berth, reading a book. The trees outside are rushing past me so fast!" Amit replies, "But from my perspective waiting here, the station platform is completely still." Meanwhile, a food vendor walks down the aisle of the moving train towards the engine. Rahul notices that the vendor seems to be moving slowly relative to him, but Amit points out that to an observer standing outside the tracks, the vendor would be moving extremely fast.

QUESTIONS:

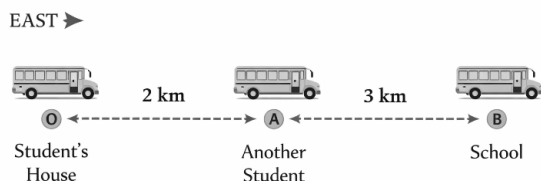
- Why does Rahul feel the trees are moving, even though trees are fixed to the ground?
- If Rahul takes the train compartment as his reference point, is he at rest or in motion? Justify.
- Compare the state of motion of the food vendor with respect to Rahul and with respect to a person standing outside the train on the ground.

Ans :

- Rahul feels the trees are moving because he is using himself or the moving train as a reference point. Since the position of the trees is changing with respect to the moving train, they appear to be in motion in the opposite direction.
- With respect to the train compartment, Rahul is at rest. This is because his position relative to the compartment does not change with time as he sits on his berth.
- With respect to Rahul, the vendor is moving slowly at normal walking speed. However, to a person on the ground, the vendor is moving much faster, because their velocity from that reference point is the sum of the train's forward velocity and the vendor's walking velocity.

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173. A school bus starts from a student's house (point O), travels 2 km East to pick up another student (point A), then travels 3 km further East to reach the school (point B). In the evening, the bus travels back along the same route, dropping the second student at point A and then returning to the first student's house (point O).



- What is the total distance covered by the bus in the morning to reach the school from the first student's house?
- What is the magnitude of the displacement of the bus in the morning from the first student's house to the school?
- What is the total distance covered by the bus for the entire round trip (from O to B and back to O)?
- What is the magnitude of the displacement of the bus for the entire round trip?

Ans :

- Total distance in the morning
 $= OA + AB$
 $= 2 \text{ km} + 3 \text{ km} = 5 \text{ km}.$

- Magnitude of displacement in the morning
 $= OB = 5 \text{ km (East)}.$
- Total distance for the entire round trip
 $= (OA + AB) + (BA + AO)$
 $= 5 \text{ km} + 5 \text{ km} = 10 \text{ km}.$
- Magnitude of displacement for the entire round trip $= 0 \text{ km}$ (since the initial and final positions are the same, point O).

174. A postwoman starts her daily route from the main post office. She drives 4 kilometers straight north along Mahatma Gandhi Road to deliver a large parcel at a school. After dropping it off, she realizes she missed a delivery at a bakery located 1 kilometer south on the exact same road. She turns her van around and drives back to the bakery. After completing this delivery, she parks her van there to take a short lunch break before continuing her route. Her smartwatch tracks her daily physical activity, showing both the total path she covered and her current distance from her starting location.

QUESTIONS:

- Calculate the total distance travelled by the postwoman from the post office to the bakery.
- Determine the magnitude of her displacement when she is resting at the bakery.
- Can the magnitude of displacement ever be greater than the total distance travelled? Give a reason based on this scenario.
- If she returns to the main post office at the end of the day, what will be her final displacement?

Ans :

- The total distance travelled is the sum of the actual path lengths. She drove 4 km north and then 1 km south. The total distance is $4 \text{ km} + 1 \text{ km} = 5 \text{ km}.$
- Displacement is the net change in position from the starting point. She went 4 km north and then returned 1 km south, leaving her 3 km north of the post office. The magnitude of her displacement is 3 km.
- No, the magnitude of displacement can never be greater than the distance travelled. Displacement is the shortest straight-line distance between initial and final positions, while distance is the entire actual path taken, which in this case was longer due to turning back.

- 166.** Abdul, while driving to school, computes the average speed for his trip to be 20 km h^{-1} . On his return trip along the same route, there is less traffic and the average speed is 30 km h^{-1} . What is the average speed for Abdul's trip?

Ans :

Let the distance of Abdul's school from his residence be $s \text{ km}$.

As during his trip from his residence to school, his average speed,

$$V_1 = 20 \text{ km h}^{-1}$$

Hence, in covering a distance $s \text{ km}$, he takes the time

$$t_1 = \frac{s}{V_1} = \frac{s}{20} \text{ h}$$

Similarly, during the return trip, he takes the time

$$t_2 = \frac{s}{V_2} = \frac{s}{30} \text{ h}$$

Average speed for Abdul's entire trip,

$$\begin{aligned} V_{av} &= \frac{\text{Total Distance}}{\text{Total Time}} \\ &= \frac{(s + s) \text{ km}}{(t_1 + t_2) \text{ h}} \\ V_{av} &= \frac{(s + s) \text{ km}}{\left(\frac{s}{20} + \frac{s}{30}\right) \text{ h}} \\ &= \frac{2s \text{ km}}{\left(\frac{s}{12}\right) \text{ h}} \\ &= 2 \times 12 \text{ km h}^{-1} \\ &= 24 \text{ km h}^{-1} \end{aligned}$$

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- 167.** A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0 m s^{-2} for 8.0 s . How far does the boat travel during this time?

Ans :

Given initial velocity of motorboat, $u = 0$

Acceleration of motorboat, $a = 3.0 \text{ m s}^{-2}$

Time under consideration, $t = 8.0 \text{ s}$

We know that distance, $s = ut + (1/2)at^2$

Therefore, the distance travel by motorboat

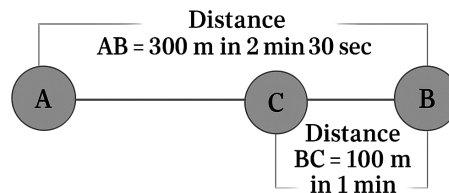
$$\begin{aligned} &= 0 \times 8 + (1/2)3.0 \times 8^2 \\ &= (1/2) \times 3 \times 8 \times 8 \text{ m} = 96 \text{ m} \end{aligned}$$

- 168.** Joseph jogs from one end A to the other end B of a straight 300 m road in $2 \text{ minutes } 30 \text{ seconds}$ and then turns around and jogs 100 m back to point C in another 1 minute . What are Joseph's average speeds and velocities in jogging (a) from A to B and (b) from A to C?

Ans : :

Total distance covered from AB = 300 m

Total time taken = $2 \times 60 + 30 \text{ s} = 150 \text{ s}$



Therefore, average speed from AB

$$\begin{aligned} &= \frac{\text{Total Distance}}{\text{Total Time}} \\ &= \frac{300}{150} \text{ ms}^{-1} = 2 \text{ m s}^{-1} \end{aligned}$$

Therefore, velocity from AB

$$\begin{aligned} &= \frac{\text{Displacement AB}}{\text{Time}} \\ &= \frac{300}{150} \text{ ms}^{-1} = 2 \text{ m s}^{-1} \end{aligned}$$

Total distance covered from AC

$$\begin{aligned} &= AB + BC \\ &= 300 + 100 \text{ m} \end{aligned}$$

Total time taken from A to C

$$\begin{aligned} &= \text{Time taken for AB} + \text{Time taken for BC} \\ &= (2 \times 60 + 30) + 60 \text{ s} = 210 \text{ s} \end{aligned}$$

Therefore, average speed from AC

$$\begin{aligned} &= \frac{\text{Total Distance}}{\text{Total Time}} \\ &= \frac{400}{210} \text{ m s}^{-1} \\ &= 1.904 \text{ m s}^{-1} \end{aligned}$$

Displacement (s) from A to C

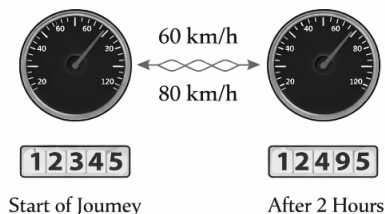
$$\begin{aligned} &= AB - BC \\ &= 300 - 100 \text{ m} \\ &= 200 \text{ m} \end{aligned}$$

Time (t) taken for displacement from AC = 210 s

Therefore, velocity from AC

$$\begin{aligned} &= \frac{\text{Displacement (s)}}{\text{Time (t)}} \\ &= \frac{200}{210} \text{ m s}^{-1} = 0.952 \text{ m s}^{-1} \end{aligned}$$

177. A car is driven on a highway. The driver notices that the speedometer reading fluctuates between 60 km/h and 80 km/h. At the start of the journey, the odometer read 12345 km, and after 2 hours of driving, it read 12495 km.



1. What physical quantity does the speedometer of the car measure at any instant? Is this quantity a scalar or a vector?
2. What physical quantity does the odometer of the car measure?
3. Calculate the total distance travelled by the car in 2 hours.
4. Calculate the average speed of the car in km/h. Can you determine the average velocity from the given information? Why or why not?

Ans :

1. The speedometer measures the instantaneous speed of the car. Speed is a scalar quantity.
2. The odometer measures the total distance travelled by the car.
3. Total distance travelled

$$= \text{Final odometer reading} - \text{Initial odometer reading}$$

$$= 12495 \text{ km} - 12345 \text{ km}$$

$$= 150 \text{ km.}$$
4. Average speed

$$= \text{Total distance} / \text{Total time taken}$$

$$= 150 \text{ km} / 2 \text{ h}$$

$$= 75 \text{ km/h.}$$

We cannot determine the average velocity from the given information because displacement is unknown. The car might not have travelled in a straight line, or it might have changed direction.

178. A group of engineering students built a high-speed remote-controlled car for a competition. During a test run on an empty basketball court, they placed the car at the starting line. When the trigger was pulled, the car zoomed straight

ahead, reaching a speed of 12 meters per second in just 4 seconds. It maintained this speed for a while. Then, the operator suddenly released the throttle and applied the electronic brakes. The car skidded smoothly in a straight line and came to a complete halt in 3 seconds to avoid hitting the boundary wall of the court.

QUESTIONS:

- (a) Calculate the average acceleration of the car during the first 4 seconds.
- (b) What is the acceleration of the car when it is maintaining the constant speed of 12 meters per second?
- (c) Calculate the average acceleration during the braking phase. What does the negative sign in your answer indicate?

Ans :

- (a) Initial velocity is 0 m/s and final velocity is 12 m/s. Time is 4 s. Average acceleration = $(\text{final velocity} - \text{initial velocity}) / \text{time} = (12 - 0) / 4 = 3 \text{ m/s}^2$.
- (b) When the car maintains a constant speed in a straight line, its velocity is not changing. Therefore, the change in velocity is zero, meaning the acceleration during this period is zero.
- (c) Initial velocity is 12 m/s, final velocity is 0 m/s, time is 3 s. Acceleration = $(0 - 12) / 3 = -4 \text{ m/s}^2$. The negative sign indicates that the acceleration is acting opposite to the direction of motion, meaning the car is slowing down (decelerating).

179. For a science fair project, Meera decides to recreate a famous experiment by dropping a heavy solid metal ball from the terrace of her four-story apartment building. She sets up a high-speed camera on a tripod on the ground to record the ball's fall. Later, she analyzes the video frame by frame. She notices that in the first second of its fall, the ball covers a relatively small distance. However, in the next second, it covers a much larger distance, and the distance covered keeps increasing for every subsequent second until it heavily impacts the sandpit she prepared on the ground.

QUESTIONS:

- (a) What kind of motion is the metal ball exhibiting as it falls?
- (b) Why does the distance covered by the ball in each successive second increase?

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- (d) If she returns to her starting point at the post office, her final displacement will be zero because there is no net change between her initial position and her final position at the end of the day.

175. During a summer sports camp, a coach is training young swimmers in a rectangular Olympic-sized pool that is 50 meters long. A young swimmer named Tara is asked to swim from one end of the pool to the other and immediately return to her starting point. She swims at a steady pace. It takes her exactly 40 seconds to reach the opposite end. She turns around without stopping and takes another 60 seconds to swim back to the starting edge, as she feels slightly tired. The coach records her timings on a clipboard to analyze her performance and explain the difference between how fast she swims and her effective progress.

QUESTIONS:

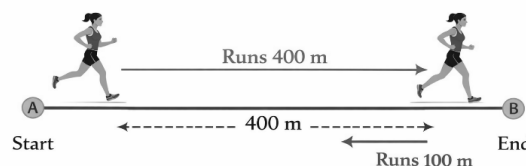
- What is the total distance covered by Tara during the entire swim?
- Calculate Tara's average speed for the entire journey.
- What is Tara's average velocity for the entire round trip?
- Why is her average velocity different from her average speed in this scenario?
- Is Tara's motion during the first 40 seconds uniform or non-uniform? Justify if she swims at a steady pace.

Ans :

- The pool is 50 meters long. Tara swims to the other end (50 m) and back (50 m). The total distance covered is $50 \text{ m} + 50 \text{ m} = 100 \text{ m}$.
- Average speed is total distance divided by total time. Total distance is 100 m. Total time is $40 \text{ s} + 60 \text{ s} = 100 \text{ s}$. Average speed is $100 \text{ m} / 100 \text{ s} = 1 \text{ m/s}$.
- Average velocity is total displacement divided by time. Since she returns exactly to her starting point, her net displacement is zero. Therefore, her average velocity is 0 m/s .
- They are different because average speed depends on the total path length covered regardless of direction, while average velocity depends on displacement, which accounts for the initial and final positions. Since she returns to the start, displacement is zero, pulling average velocity to zero despite a non-zero distance.

- (e) If she swims at a perfectly steady pace, covering equal distances in equal intervals of time during that straight-line stretch, her motion for those first 40 seconds is uniform motion.

176. An athlete runs on a straight 400 m track. She starts at one end, runs to the other end, and immediately turns back and runs 100 m towards the starting point before stopping. The entire activity takes her 80 seconds.



- What is the total distance covered by the athlete?
- What is the magnitude of the athlete's displacement from her starting point?
- Calculate the average speed of the athlete.
- Calculate the magnitude of the average velocity of the athlete.

Ans :

- Total distance covered
 $= 400 \text{ m (to the end)} + 100 \text{ m (back)}$
 $= 500 \text{ m}$
- Magnitude of displacement
 $= \text{Distance from start to finish}$
 $= 400 \text{ m} - 100 \text{ m}$
 $= 300 \text{ m from the starting point}$
- Average speed
 $= \text{Total distance} / \text{Total time}$
 $= 500 \text{ m} / 80 \text{ s}$
 $= 6.25 \text{ m/s}$
- Magnitude of average velocity
 $= \text{Magnitude of displacement} / \text{Total time}$
 $= 300 \text{ m} / 80 \text{ s}$
 $= 3.75 \text{ m/s}$

Ans :

1. As the ball moves upwards, its velocity decreases continuously due to gravity. At the maximum height, its velocity is momentarily zero.
2. The acceleration acting on the ball is the acceleration due to gravity (g), which is always directed downwards, both during its upward motion and its downward motion.
3. It will take the same time ' t ' seconds to fall back to the thrower's hand from the maximum height (in the absence of air resistance).
4. The speed of the ball is zero at its maximum height. The acceleration of the ball is never zero as long as it is in free flight under gravity; it is always ' g ' directed downwards.

- 182.** The control room of a modern metro train monitors the performance of its automated trains using live graphs on large screens. One of the screens displays a velocity-time graph for Train Alpha traveling between two stations on a straight track. The graph begins at the origin and rises as a straight inclined line for 20 seconds. It then flattens out into a horizontal line for 60 seconds. Finally, the line slopes downwards in a straight line, reaching the time axis after another 15 seconds as the train arrives safely at the next platform.

QUESTIONS:

- (a) Describe the acceleration of Train Alpha during the first 20 seconds and the last 15 seconds based on the graph shapes.
- (b) What is the acceleration of the train during the 60-second middle phase? Justify your answer.
- (c) How can the control room operators calculate the total displacement between the two metro stations using this specific graph?

Ans :

- (a) During the first 20 seconds, the straight upward inclined line indicates constant positive acceleration. During the last 15 seconds, the straight downward inclined line indicates constant negative acceleration (retardation or slowing down).
- (b) The acceleration during the 60-second middle phase is zero. A horizontal line on a velocity-time graph means the velocity is constant, and since there is no change in velocity over time, the acceleration is zero.

- (c) The total displacement between the stations can be calculated by finding the area enclosed between the velocity-time graph line and the time axis (x -axis) for the entire 95-second duration of the journey.

- 183.** A small commercial airplane is preparing for takeoff on a newly constructed runway. The pilot pushes the throttle, and the aircraft starts from rest, accelerating uniformly down the straight tarmac. It takes the airplane 30 seconds to reach its critical takeoff velocity of 60 meters per second, at which point the wheels leave the ground. An aviation engineer observing the takeoff notes down these parameters to ensure the runway is long enough to meet safety regulations. They must verify the acceleration and the minimum runway distance required for this specific type of aircraft under current weather conditions.

QUESTIONS:

- (a) State the initial velocity of the airplane.
- (b) Using the given data, calculate the uniform acceleration of the airplane during its takeoff roll.
- (c) Which kinematic equation is most direct to calculate the distance covered before takeoff, once acceleration is known and time is given?
- (d) Calculate the total distance the airplane travels along the runway before lifting off.
- (e) If a heavier cargo plane requires the same takeoff velocity but has a lower uniform acceleration, how will this affect the required runway length?

Ans :

- (a) Since the airplane starts from rest on the runway, its initial velocity is 0 m/s.
- (b) Initial velocity (u) = 0 m/s,
final velocity (v) = 60 m/s,
time (t) = 30 s.

Using the equation

$$v = u + at$$

we get $60 = 0 + a(30).$

Therefore,

acceleration $(a) = 60 / 30 = 2 \text{ m/s}^2$

- (c) The equation $s = ut + (1/2)at^2$ is the most direct way to calculate distance (s) since initial velocity (u), time (t), and acceleration (a) are known.

- (c) Assuming air resistance is negligible, is the average acceleration of the ball constant or changing during its fall?
- (d) What is the specific name and approximate value of the acceleration experienced by this falling object?

Ans :

- (a) The metal ball is exhibiting accelerated motion in a straight line, specifically downward motion under gravity.
- (b) The distance increases because the velocity of the ball is continuously increasing as it falls. Since it is moving faster with each passing second, it covers more ground in the same one-second time interval.
- (c) The average acceleration of the ball remains constant throughout its fall. Its velocity increases by equal amounts in equal intervals of time.
- (d) This constant acceleration is called acceleration due to gravitational force (or 'g'), and its approximate value near the Earth's surface is 9.8 m/s^2 .

180. A biologist is studying the foraging behavior of a specific species of desert ant. She places a food source a few meters away from the ant nest and records the position of an ant moving along a straight measuring tape over time. She plots a position-time graph of the ant's journey. The graph shows a straight line sloping upwards starting from the origin for the first 10 seconds. Then, the graph becomes a horizontal line parallel to the time axis for 5 seconds. Finally, the graph shows a curved line sloping upwards at an increasing steepness for the remaining time until the ant reaches the food.

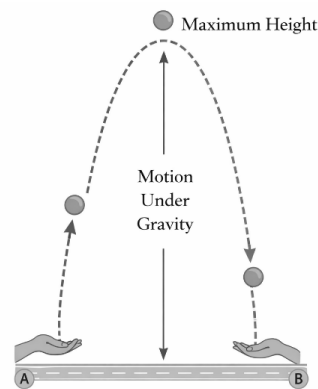
QUESTIONS:

- (a) What does the straight upward-sloping line in the first 10 seconds indicate about the ant's velocity?
- (b) Interpret the ant's motion during the 5-second interval where the graph is horizontal.
- (c) What can you infer about the ant's acceleration during the final phase where the graph is a curved line?
- (d) How could the biologist calculate the exact speed of the ant during the first 10 seconds from this graph?

Ans :

- (a) The straight upward-sloping line indicates that the ant is moving with a constant velocity. It is covering equal distances in equal intervals of time.
- (b) A horizontal line on a position-time graph means the position is not changing with time. The ant has stopped moving and is at rest during those 5 seconds.
- (c) A curved line with increasing steepness indicates that the slope (which represents velocity) is increasing. This means the ant is exhibiting accelerated motion, moving faster as time passes.
- (d) The biologist can calculate the speed by finding the slope of the straight line in that interval. This is done by selecting two points on the line and dividing the change in position (y-axis) by the corresponding change in time (x-axis).

181. A ball is thrown vertically upwards with an initial velocity. It reaches a maximum height and then falls back to the thrower's hand. (Consider only the motion under gravity, ignoring air resistance).



- 1. Describe the change in velocity of the ball as it moves upwards. What is the velocity at the maximum height?
- 2. What is the direction of acceleration acting on the ball during its upward motion? What about during its downward motion?
- 3. If the ball takes 't' seconds to reach the maximum height, how much time will it take to fall back to the thrower's hand from the maximum height?
- 4. When is the speed of the ball zero? When is its acceleration zero (assuming it is always under the influence of gravity after being thrown)?

- (c) During the 1-second reaction time, the car continues to travel at a constant speed of 20 m/s. Distance = speed $\times$ time = 20 m/s $\times$ 1 s = 20 meters.
- (d) A wet road reduces friction between the tires and the surface, which decreases the car's braking capacity (lowers the magnitude of negative acceleration). This reduced deceleration causes the car to travel a much greater distance before stopping.

186. A group of children are playing in a park that has a large merry-go-round. The merry-go-round is spinning at a steady, constant rate. Rohan stands on the outer edge, 2 meters away from the center pole, holding tightly to the metal bars. His friend Maya stands halfway closer, only 1 meter from the center. A science teacher watching them notes that although the ride is spinning smoothly and steadily, both children are actually undergoing accelerated motion. Suddenly, a tennis ball falls out of Rohan's pocket and hits the smooth concrete floor of the park while the ride is moving.

QUESTIONS:

- (a) If the merry-go-round rotates at a constant speed, why does the teacher say the children are undergoing accelerated motion?
- (b) Compare the distance traveled by Rohan and Maya during one complete revolution of the merry-go-round.
- (c) In which direction will the tennis ball move horizontally immediately after it slips from Rohan's pocket?

Ans :

- (a) Even though the speed is constant, the direction of motion for both children is changing continuously as they move in a circular path. Since velocity is a vector quantity, a change in direction means a change in velocity, which results in acceleration.
- (b) The distance traveled in one revolution is the circumference of their respective circular paths (2π radius). Since Rohan's radius (2 m) is twice Maya's radius (1 m), Rohan travels twice the distance Maya does in one complete revolution.
- (c) Due to inertia, the tennis ball will move in a straight line along the tangent to the circular path at the exact point where it fell from Rohan's pocket.

187. A train starts from rest and its velocity-time graph is a straight line with a positive slope for the first 10 seconds. Then, for the next 30 seconds, the graph is a horizontal line. Finally, for the last 5 seconds, the graph is a straight line with a negative slope, reaching zero velocity.

1. What type of motion does the train exhibit in the first 10 seconds? What can you say about its acceleration?
2. Describe the motion of the train during the next 30 seconds (from 10 s to 40 s). What is its acceleration during this period?
3. What type of motion does the train exhibit in the last 5 seconds?
4. How can the total distance travelled by the train be calculated from this velocity-time graph?

Ans :

1. In the first 10 seconds, the train exhibits uniformly accelerated motion (velocity increases uniformly with time). Its acceleration is constant and positive.
2. During the next 30 seconds, the train moves with uniform velocity (constant velocity). Its acceleration during this period is zero.
3. In the last 5 seconds, the train exhibits uniform deceleration (or retardation) as its velocity uniformly decreases to zero. The acceleration is constant and negative.
4. The total distance travelled by the train can be calculated by finding the area under the velocity-time graph for the entire duration of its motion.

188. A car, initially at rest, accelerates uniformly at a rate of 2 m/s^2 for 5 seconds.

1. What is the initial velocity (u) of the car?
2. What is the acceleration (a) of the car?
3. Using the first equation of motion ($v = u + at$), calculate the final velocity (v) of the car after 5 seconds.
4. Using the second equation of motion ($s = ut + \frac{1}{2}at^2$), calculate the distance (s) covered by the car in these 5 seconds.

Ans :

1. The initial velocity (u) of the car is 0 m/s (since it starts from rest).
2. The acceleration (a) of the car is 2 m/s^2 .
3. Final velocity

$$v = u + at$$

$$= 0 + (2 \text{ m/s}^2 \times 5 \text{ s}) = 10 \text{ m/s}$$

transition of a substance from a liquid state into a vapour.

9. Clouds are made up of tiny water droplets or ice crystals floating in the air. Based on what you know about solutions, suspensions and colloids, what type of mixture do you think clouds are and why?

Ans :

Clouds are a type of colloidal mixture, specifically referred to as an aerosol. In this mixture, the tiny water droplets or ice crystals act as the dispersed phase which is suspended evenly throughout the air, serving as the dispersion medium. Unlike suspensions, these tiny particles do not settle down under the influence of gravity over time.

10. Why do cities with a lot of smoke and dust in the air often look hazy?

Ans :

Cities with significant smoke and dust look hazy because of the Tyndall effect. The fine dust and smoke particles suspended in the atmosphere act as colloidal particles. When sunlight passes through the air, these particles scatter the light in all directions, making the path of light visible and giving the city's air a hazy, unclear appearance.

NCERT EXERCISE

1. Which of the following mixtures are correctly classified as homogeneous (Hm) and heterogeneous (Ht)? Choose the correct option.
- Air — Hm, Milk — Ht, Sugar solution — Hm, Smoke — Hm
 - Brass — Ht, Fog — Ht, Vinegar — Ht, Muddy water — Hm
 - Copper sulfate solution — Hm, Salt solution — Hm, Milk — Hm, Bronze — Hm
 - Muddy water — Ht, Milk — Ht, Blood — Ht, Brass — Hm

Ans :

Option (iv) is the correct choice. Muddy water, milk, and blood are all heterogeneous mixtures (specifically suspensions or colloids) because their compositions are not uniform throughout, whereas brass is an alloy, which is considered a homogeneous mixture of metals.

2. Choose the correct options, and explain the reason for the correct and incorrect options.

Which among the following mixtures show the Tyndall Effect?

A mixture of:

- air and dust particles
 - copper sulfate and water
 - starch and water
 - acetone and water
- a and b
 - b and d
 - a and c
 - c and d

Ans :

Option (iii) a and c is correct. The Tyndall effect is the scattering of a beam of light by particles in a colloid or fine suspension. A mixture of air and dust particles (an aerosol) and a mixture of starch and water are both colloids, possessing particles large enough to scatter light, making them correct options. On the other hand, copper sulfate in water and acetone in water form true solutions; their solute particles are too small (less than 1 nm in diameter) to scatter light, making them incorrect options.

3. A mixture can be categorised as a solution, a suspension, or a colloid, each possessing distinct properties. Utilise the words or phrases provided in the box to fill in the Table. Words and phrases may be used more than once.

Words and Phrases

Large-sized particles; Particles remain evenly distributed; Small-sized particles (less than 1 nm diameter); Moderate-sized particles (1–1000 nm); Settles down when left undisturbed (more than 1000 nm in diameter); Does not settle down; Scatters light; Separates by filtration; Transparent; Salt solution; Milk; Sand in water; Smoke; Heterogeneous mixture; Cannot be separated by filtration; Mud; Butter; Brass.

Solution	Suspension	Colloid
Properties	Properties	Properties
Examples	Examples	Examples

CHAPTER 5

Exploring Mixtures and their Separation

SUMMARY

1. HOW CAN WE CLASSIFY MIXTURES?

1. Mixtures are classified as either homogeneous or heterogeneous.
2. A homogeneous mixture has a uniform composition throughout.
3. A well-stirred mixture of sugar and water is a homogeneous mixture.
4. A homogeneous mixture is also called a solution.
5. Other examples of homogeneous mixtures are vinegar and aerated drinks like soda.
6. A heterogeneous mixture does not have a uniform composition.
7. A mixture of sand and water is a heterogeneous mixture.
8. Particles in a heterogeneous mixture like sand and water are easily visible.
9. Light passes directly through a true solution without being scattered.
10. Light scatters when passed through certain heterogeneous mixtures like milk in water.

2. SOLUTIONS

1. Solutions are homogeneous mixtures.
2. A solution is prepared when a solute gets dissolved in a solvent.
3. The solute is the substance that gets dissolved.
4. The solvent is the substance that dissolves the solute.
5. In a mixture of sugar and water, sugar is the solute and water is the solvent.

2.1 Concentration of a solution

1. The exact proportion of solute and solvent is essential when preparing a solution.

2. Dilip Mahalanabis was an Indian paediatrician who developed the Oral Rehydration Solution (ORS).
3. ORS is used to treat dehydration caused by diseases like diarrhoea and cholera.
4. Too little or too much pesticide mixed with water can fail to protect crops or damage the soil.
5. The amount of solute dissolved in a given amount of solvent or solution is termed the concentration of the solution.
6. Understanding concentration is essential in laboratories, medicine, agriculture, and daily life.

2.2 How do we express concentration?

1. The concentration of a solution can be expressed as a percentage.
2. Mass by mass percentage tells how many grams of solute are present in 100 grams of the total solution.
3. This is mathematically written as: $\text{Mass by mass percentage} = (\text{Mass of solute} / \text{Mass of solution}) \times 100$.
4. This is expressed as % m/m or % w/w.
5. Mass by mass percentage is also used to label packaged foods like milk powder and spice mixtures.
6. Mass by volume percentage tells how many grams of the solute are present in 100 millilitres of the solution.
7. This is mathematically written as: $\text{Mass by volume percentage} = (\text{Mass of solute} / \text{Volume of solution}) \times 100$.
8. This is expressed as % m/v or % w/v.
9. Mass by volume percentage is easier to use for liquids, such as medicines and intravenous glucose solutions.
10. Volume by volume percentage is used when two miscible liquids are mixed.

$$\begin{aligned}
 4. \quad \text{Distance } s &= ut + \frac{1}{2}at^2 \\
 &= (0 \times 5) + \frac{1}{2} \times (2\text{m/s}^2) \times (5\text{s})^2 \\
 &= 0 + \frac{1}{2} \times 2 \times 25 = 25\text{m}
 \end{aligned}$$

189. A cyclist is moving at a speed of 10 m/s. She applies brakes, which produce a uniform deceleration (negative acceleration) of 1 m/s², bringing the bicycle to rest.

1. What is the initial velocity (u) of the bicycle?
2. What is the final velocity (v) of the bicycle?
3. What is the acceleration (a) of the bicycle (remember it's deceleration)?
4. Using the third equation of motion ($v^2 - u^2 = 2as$), calculate the distance (s) the bicycle travels before coming to rest.

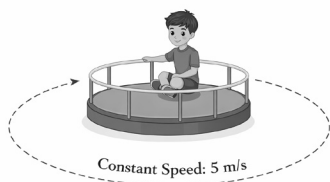
Ans :

1. The initial velocity (u) of the bicycle is 10 m/s.
2. The final velocity (v) of the bicycle is 0 m/s (comes to rest).
3. The acceleration (a) of the bicycle is -1 m/s² (deceleration).
4. Using

$$\begin{aligned}
 v^2 - u^2 &= 2as \\
 (0)^2 - (10\text{m/s})^2 &= 2 \times (-1\text{m/s}^2) \times s \\
 0 - 100 &= -2s \\
 -100 &= -2s \\
 s &= \frac{-100}{-2} = 50\text{ m}
 \end{aligned}$$

The bicycle travels 50 meters before coming to rest.

190. A child is sitting on a merry-go-round that is moving at a constant speed of 5 m/s. The merry-go-round completes one full circle.



1. Is the velocity of the child constant? Explain your answer.
2. Is the child accelerating? Explain why or why not.
3. What is this type of motion called when an object moves in a circular path with uniform speed?

4. If the radius of the merry-go-round is 7 meters, and it completes one circle in 8.8 seconds, verify if the speed is approximately 5 m/s. (Use $\pi \approx 22/7$)

Ans :

1. No, the velocity of the child is not constant. Although the speed is constant, the direction of motion is continuously changing as the child moves in a circle. Velocity is a vector quantity (having both magnitude and direction).
2. Yes, the child is accelerating. Since the direction of velocity is changing, there is an acceleration (called centripetal acceleration), even though the speed is constant.
3. This type of motion is called uniform circular motion.
4. Circumference

$$= 2\pi r = 2 \times (22/7) \times 7\text{m} = 44\text{m}$$

Speed = Distance / Time

$$= 44\text{ m} / 8.8\text{ s} = 5\text{ m/s.}$$

Yes, the speed is approximately 5 m/s.

191. A stone is dropped from the top of a tall building. It falls freely under gravity. Let's assume the acceleration due to gravity (g) is 10m/s².

1. What is the initial velocity of the stone when it is dropped?
2. What is the acceleration of the stone as it falls? Is this acceleration uniform or non-uniform (for free fall near Earth's surface)?
3. If the stone takes 3 seconds to reach the ground, what will be its velocity just before it hits the ground?
4. What is the nature of the distance-time graph for an object in free fall?

Ans :

1. The initial velocity of the stone when dropped is 0 m/s.
2. The acceleration of the stone is the acceleration due to gravity, g (approximately 10m/s² downwards). For free fall near the Earth's surface, this acceleration is considered uniform.
3. Using $v = u + at$ (where $a = g$):

$$v = 0 + (10\text{m/s}^2 \times 3\text{s}) = 30\text{m/s.}$$

4. The distance-time graph for an object in free fall (uniformly accelerated motion starting from rest) will be a curve (parabola) showing that the distance covered increases non-linearly with time ($s \propto t^2$).

3.3 Paper Chromatography

1. Paper chromatography separates the components of a mixture based on how fast they move.
2. The word chromatography comes from the Greek word chroma meaning colour.
3. It was first used to separate coloured substances like dyes and inks.
4. The method uses interactions between the solvent, the paper, and the components of the mixture.
5. A spot of the mixture is placed on a strip of chromatographic paper or filter paper.
6. The paper is dipped into a solvent like water or alcohol.
7. The solvent level must remain below the mixture spot at the start.
8. As the liquid rises up the paper, it carries the substances and separates them into different colour spots.
9. This method can separate pigments in ink, spinach leaves, or flower petals.

4. HOW CAN WE SEPARATE THE COMPONENTS OF HETEROGENEOUS MIXTURES?

Heterogeneous mixtures are separated using different techniques based on the physical properties of their components.

4.1 Separation of two immiscible liquids

1. Immiscible liquids do not mix with each other and form separate layers.
2. Oil and water are immiscible liquids.
3. A separating funnel is used to separate a mixture of two immiscible liquids.
4. The mixture is poured into the funnel and left undisturbed to form layers.
5. The lighter liquid forms the upper layer and the heavier liquid forms the lower layer.
6. The stopcock is opened to slowly drain and collect the lower layer into a container.
7. The small middle portion containing both liquids is discarded.
8. The upper layer is then collected in a separate container.
9. Most gas mixtures are homogeneous because gas particles move freely and mix uniformly.
10. Most solid-solid mixtures are heterogeneous.

4.2 Sublimation

1. Sublimation is the process where a solid changes directly into a vapour on heating without passing through the liquid state.
2. Deposition is the reverse process where vapours cool and change directly back into a solid without becoming a liquid.
3. Camphor, naphthalene, and dry ice undergo sublimation.
4. A mixture of a sublimable solid and a non-sublimable solid can be separated by heating.
5. The mixture is heated in a china dish covered with an inverted glass funnel.
6. The funnel nozzle is plugged with cotton.
7. The sublimable substance vaporises and condenses as a pure solid on the cooler inner walls of the funnel.
8. The non-sublimable substance is left behind in the dish.
9. Alloys are homogeneous mixtures of two or more metals, or a metal and a non-metal.
10. Alloys cannot be separated by physical methods.
11. Brass is an alloy of about 80 percent copper and 20 percent zinc.
12. Bronze is an alloy of about 80 percent copper and 20 percent tin.
13. Stainless steel is an alloy of iron, carbon, chromium, nickel, and molybdenum.

4.3 Suspensions

1. A suspension is a heterogeneous mixture where solid particles do not dissolve but remain suspended.
2. Particles in a suspension are visible to the naked eye.
3. The particles are larger in size than those present in a solution.
4. Muddy water, sawdust in water, and tea leaves in water are examples of suspensions.
5. Suspended particles can sometimes be separated by leaving the mixture undisturbed to settle, followed by filtration.

A. Centrifugation

1. Centrifugation involves spinning a mixture in a tube at a high speed to separate it.
2. A centrifugal force pushes outward on the heavier particles moving in circular motion.

11. It tells how many millilitres of the solute are present in 100 millilitres of the solution.
12. This is mathematically written as: Volume by volume percentage = $(\text{Volume of solute} / \text{Volume of solution}) \times 100$.
13. This is expressed as % v/v and is used for items like perfumes and vinegar.

2.3 Solubility of substances

1. Solubility is the maximum amount of solute that dissolves in a fixed quantity of a solvent at a given temperature.
2. A saturated solution is a solution that cannot dissolve any more solute at a given temperature.
3. Temperature must be mentioned because solubility changes with temperature.
4. The solubility of a solid solute in a liquid solvent generally increases with an increase in temperature.
5. The solubility of gases dissolved in liquids generally decreases with an increase in temperature.
6. A graph showing solubility against temperature is called a solubility curve.
7. In a solubility curve, the x-axis shows temperature and the y-axis shows solubility in grams per 100 grams of water.
8. Different substances have different solubility levels at the same temperature.

3. METHODS OF SEPARATION OF HOMOGENEOUS MIXTURES

Homogeneous mixtures require specific separation methods to recover the dissolved components.

3.1 Crystallization

1. Crystallization is the process of forming crystals from a saturated solution.
2. A crystal is a solid made up of particles arranged in a regular geometric pattern.
3. Examples of natural crystals include rock salt, candy sugar, snowflakes, frost, and quartz.
4. In laboratories, crystallization separates a pure solid from a solution or purifies a solid mixture.
5. The principle is based on the differences in the solubility of a substance at different temperatures.

6. When a hot saturated solution is cooled slowly, the pure substance separates out as crystals.
7. Adding a drop of dilute sulfuric acid during copper sulfate crystallization prevents unwanted reactions.
8. Rapid cooling of a hot saturated solution forms smaller and less well-formed crystals.
9. Slow cooling allows particles enough time to come together to form larger, shiny crystals.
10. Ancient coastal communities in India produced panga salt by boiling sea brines.
11. They also produced karkatch salt by solar evaporation of sea water.

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3.2 Distillation

1. Distillation is used to separate a homogeneous mixture of two miscible liquids.
2. It requires the liquids to have a minimum difference of 25 degrees Celsius in their boiling points.
3. The mixture is heated until the liquid with the lower boiling point vaporises.
4. The vapour is passed through a condenser where it is cooled by circulating water or air.
5. The vapour condenses back into a pure liquid called the distillate.
6. The pure liquid collects in a separate vessel while the other liquid remains in the distillation flask.
7. Distillation can also separate a liquid solvent from a solution containing dissolved solids.
8. The Deg-Bhapka method is a traditional distillation method used in Kannauj, Uttar Pradesh.
9. It is used to extract fragrances from flowers to make natural perfumes like Mitti ka Ittar.
10. Fractional distillation is used to separate components with boiling point differences less than 25 degrees Celsius.
11. Petroleum refineries use fractional distillation to separate crude oil into useful products.
12. These products include petroleum gas, petrol, kerosene, diesel, and lubricating oil.

2. Your mother gives you a bottle of orange juice concentrate to mix with water and serve it to your visiting friends. She asks you to mix two tablespoons of the concentrate with water in a glass tumbler. If each tablespoon measures 15 mL and you make 150 mL of juice per person, what is the % v/v of orange juice concentrate in the mixture you prepared?

Ans :

The concentration of the orange juice mixture is 20% v/v. The volume of the solute is 30 mL (two tablespoons of 15 mL each), which is divided by the total volume of the solution (150 mL) and then multiplied by 100 to find the volume by volume percentage.

3. Vinegar, used as a food preservative and additive, contains 5 % v/v acetic acid. Glacial acetic acid is a liquid, i.e., 100% acetic acid. If you want to make vinegar from glacial acetic acid, how would you proceed?

Ans :

To make vinegar, you need to prepare a 5% v/v solution of acetic acid. You would proceed by measuring 5 mL of the glacial acetic acid (solute) and mixing it with enough water (solvent) to reach a total combined volume of 100 mL.

4. Refer to the solubility curves given in Activity 5.2. If equal masses of hot, saturated solutions of compounds 'A' and 'B' are cooled from 80 degrees C to 60 degrees C, which solution is likely to deposit more solid?

Ans :

The solution of compound 'B' is likely to deposit more solid. According to the solubility curves, compound 'B' shows a much steeper decrease in solubility as the temperature drops from 80 degrees C to 60 degrees C compared to compound 'A', meaning a larger amount of excess solute will crystallize and separate out.

5. Will there be any change in the size of common salt crystals if the rate of evaporation is increased or decreased? Explain.

Ans :

Yes, the rate of evaporation directly affects the size of the crystals formed. If the rate of evaporation is decreased by allowing the solution to cool slowly, the particles have more time to come together and arrange themselves, resulting

in larger, well-shaped crystals. Conversely, if evaporation is increased and happens too rapidly, smaller and less well-formed crystals will develop.

6. State whether the following statements are True or False. Also, correct the False statements.

- Salt can be separated from a salt solution by evaporation or distillation.
- Distillation can be used for separation of two liquids even when these have the same boiling point.
- In paper chromatography, the solvent level should be above the sample spot at the beginning of the experiment.
- Evaporation and crystallization are the same processes.

Ans :

- True.
- False. Correction: Distillation can only be used to separate two miscible liquids if they have different boiling points, typically requiring a minimum difference of 25 degrees C.
- False. Correction: In paper chromatography, the solvent level should be strictly below the sample spot at the beginning of the experiment so that the liquid can slowly carry the substances up the paper rather than dissolving them directly into the bulk solvent.
- False. Correction: Evaporation simply involves turning a solvent into vapour to leave behind a solid, which may contain impurities, whereas crystallization is a specific process that yields a pure solid in a regular geometric pattern from a saturated solution.

7. Why do immiscible liquids form two separate layers in a separating funnel?

Ans :

Immiscible liquids form two separate layers because they do not mix together and they possess different densities. When the mixture is left undisturbed, the denser liquid sinks to the bottom to form the lower layer, while the lighter, less dense liquid floats to form the upper layer.

8. Is sublimation different from evaporation? Justify.

Ans :

Yes, sublimation is distinctly different from evaporation. Sublimation is the direct transition of a solid into a vapour without ever passing through a liquid state, whereas evaporation is the

6. **Assertion (A):** Solutions do not exhibit the Tyndall effect.

Reason (R): The particles in solutions are larger than 100 nm, so they cannot scatter light.

Choose the correct option:

- (i) Both A and R are true, and R is the correct explanation of A.
- (ii) Both A and R are true, but R is not the correct explanation of A.
- (iii) A is true, but R is false.
- (iv) A is false, but R is true.

Ans :

Option (iii) is the correct choice. The assertion is true because true solutions are homogeneous mixtures that do not scatter light. However, the reason is false because the solute particles in a solution are extremely small (less than 1 nm in diameter), not larger than 100 nm; it is precisely their small size that prevents them from scattering a light beam.

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7. How would you separate the mixtures given in Table? Mention the reason for choosing your method. If a mixture cannot be separated, explain why.

Mixture	Method of separation	Reason for selection
Mud from muddy water		
Plasma from other components in the blood sample		
Naphthalene and sand		
Chalk powder and common salt		
Common salt and water		
Oil from water		
Pigments of the flower		

Ans :

Mixture	Method of Separation	Reason for Selection
Mud from muddy water	Filtration	Mud particles are insoluble solids suspended in the water and are large enough to be retained by a filter paper.
Plasma from other components in the blood sample	Centrifugation	Spinning the blood at high speeds applies centrifugal force, causing the heavier blood cells to settle at the bottom while the lighter liquid plasma remains at the top due to density differences.
Naphthalene and sand	Sublimation	Naphthalene is a sublimable substance that transitions directly from a solid to a vapour on heating, leaving the non-sublimable sand behind.
Chalk powder and common salt	Dissolution in water followed by filtration	Common salt is soluble in water while chalk powder is insoluble. After dissolving the salt, filtration separates the solid chalk, and the pure salt can be recovered later by evaporating the filtrate.
Common salt and water	Evaporation	Heating the solution causes the volatile solvent (water) to vaporize, leaving behind the non-volatile solid solute (common salt).

Complete the Table

Ans :

Solution	Suspension	Colloid
Properties	Properties	Properties
Homogeneous mixture	Heterogeneous mixture	Heterogeneous (appears homogeneous)
Particle size: less than 1 nm (small particles)	Particle size: more than 1000 nm (large particles)	Particle size: between 1 nm and 1000 nm
Transparent	Opaque	Translucent
Particles do not scatter light	Particles scatter light strongly	Particles scatter light (Tyndall effect)
Stable; particles do not settle down	Unstable; particles settle down on standing	Quite stable; particles do not settle down
Cannot be separated by filtration	Can be separated by filtration	Cannot be separated by ordinary filtration
Examples	Examples	Examples
Salt solution, sugar solution	Muddy water, sand in water	Milk, butter, smoke

4. Solve the following problems:

- A cake recipe uses dry ingredients, namely 75 g of sugar for 420 g of all-purpose flour and 5 g of sodium hydrogencarbonate. Express the concentration of each component in the mixture using an appropriate method.
- A brass alloy contains 70% copper by mass. Calculate the quantities of copper and zinc present in 120 g of brass.

Ans :

- We can use the mass by mass percentage (% m/m) method.

First, calculate the total mass of the mixture:
 $75 \text{ g (sugar)} + 420 \text{ g (flour)} + 5 \text{ g (sodium hydrogencarbonate)} = 500 \text{ g}.$

Concentration of sugar

$$= (\text{Mass of sugar} / \text{Total mass}) 100$$

$$= (75 / 500) 100 = 15\% \text{ m/m}.$$

Concentration of all-purpose flour

$$= (\text{Mass of flour} / \text{Total mass}) 100$$

$$= (420 / 500) 100 = 84\% \text{ m/m}.$$

Concentration of sodium hydrogencarbonate

$$= (\text{Mass of sodium hydrogencarbonate} / \text{Total mass}) 100$$

$$= (5 / 500) 100 = 1\% \text{ m/m}.$$

- Mass of the brass alloy is 120 g.

Quantity of copper

$$= 70\% \text{ of total mass}$$

$$= (70 / 100) 120 \text{ g} = 84 \text{ g}.$$

Assuming the rest of the alloy is zinc, the percentage of zinc is $100\% - 70\% = 30\%$.

Quantity of zinc

$$= 30\% \text{ of total mass}$$

$$= (30 / 100) 120 \text{ g}$$

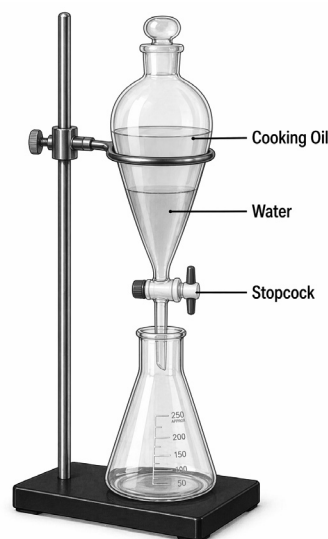
$$= 36 \text{ g (Alternatively, } 120 \text{ g total} - 84 \text{ g copper}$$

$$= 36 \text{ g zinc)}$$

- The label on a cooking oil pack says one litre (910 g). If this oil is mixed with water, will it form a separate layer? If so, which substance will be on top? How will you separate the two layers? Also, draw the diagram of the apparatus used.

Ans :

Yes, the oil and water will form separate layers because they are immiscible liquids. Based on the label, the density of the oil is 910 g per 1000 mL (0.91 g/mL), which is less than the density of water (approximately 1 g/mL). Because it is lighter, the cooking oil will float and form the top layer. The two layers can be separated using a separating funnel.



3. Heavier particles settle at the bottom of the tube while the lighter liquid remains at the top.
4. Centrifugation is widely used in laboratories to separate blood components like red blood cells and plasma.
5. A paperfuge is a simple hand-powered device made of a cardboard disc and string.
6. It performs centrifugation without electricity by spinning blood samples at high speed.
7. It is a low-cost tool used to detect diseases like malaria in remote areas.

B. Coagulation

1. Coagulation is the process of adding a substance to make fine suspended particles clump together.
2. The substance added to cause this clumping is called a coagulant.
3. Powdered alum is a white crystalline chemical substance used as a coagulant for water purification.
4. Alum causes fine mud particles to clump together into larger, heavier clumps.
5. These heavier clumps settle down by gravity in a process called sedimentation.
6. The clear water can then be separated by decantation or filtration.
7. The formation of cheese or paneer from milk also involves coagulation.
8. Acids like lemon juice or vinegar act as coagulants to clump milk proteins together.

4.4 Colloids

1. A colloid is a mixture that appears homogeneous but is actually heterogeneous.
2. Blood, milk, tomato sauce, and ice cream are examples of colloids.
3. Particles in a colloid are larger than particles in a solution but smaller than particles in a suspension.
4. The particle size of a solute in a solution is less than 1 nanometre in diameter.
5. Colloid particles range from 1 to 1000 nanometres in diameter.
6. Suspension particles are larger than 1000 nanometres in diameter.
7. Particles in a colloid do not settle over time and remain uniformly dispersed in the mixture.

8. A colloid cannot be separated by simple filtration.

5. TYNDALL EFFECT

1. The Tyndall effect is the scattering of light by particles in a mixture, making the path of light visible.
2. It is named after the scientist John Tyndall who first explained the scattering of light by particles.
3. The Tyndall effect occurs when light passes through a colloid or a suspension.
4. It does not occur when light passes through a transparent true solution.
5. Examples include sunlight entering a dark room through a hole and scattering off dust particles.
6. Another example is light scattering from floodlights in a misty sports stadium.
7. A colloid has two main components called the dispersed phase and the dispersion medium.
8. The dispersed phase is the solute-like component or the dispersed particles in a colloid.
9. The dispersion medium is the component in which the dispersed phase is suspended.
10. Emulsions are a specific type of colloid where both the dispersed phase and the dispersion medium are liquids.
11. Oil-in-water emulsions include milk and vanishing creams.
12. Water-in-oil emulsions include butter, body lotions, and cold cream.
13. Emulsifying agents are added to stabilize emulsions and keep them from separating.
14. Proteins in milk and butter act as natural emulsifying agents.

PAUSE AND PONDER

1. A common talcum powder contains 4 % m/m zinc oxide, which acts as an antiseptic. How much zinc oxide is present in 300 g of the talcum powder?

Ans :

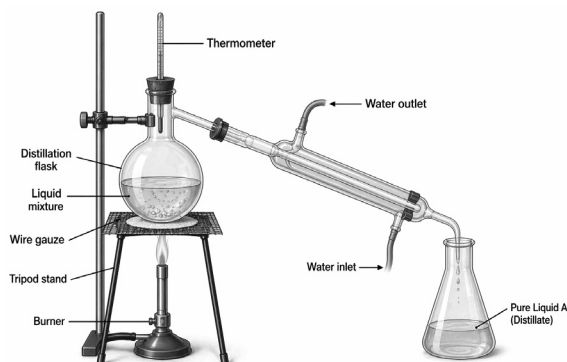
There are 12 grams of zinc oxide present in the powder. This is calculated using the mass by mass percentage formula, where 4% of the total 300 g mass of the mixture is the zinc oxide solute.

Oil from water	Separating funnel	Oil and water are immiscible liquids with different densities, meaning they do not mix and naturally separate into distinct layers that can be drained off one by one.
Pigments of the flower	Paper chromatography	The different coloured pigments have varying degrees of solubility in the solvent; as the solvent travels up the chromatography paper, the more soluble pigments move faster and separate from the others.

8. Two miscible liquids, A and B, are present in a mixture. The boiling point of A is 60°C and the boiling point of B is 90°C . Suggest a method to separate them. Also, draw a labelled diagram of the method suggested.

Ans :

Since A and B are miscible liquids with a boiling point difference of 30°C (which is greater than the required 25°C minimum difference), they can be successfully separated using the process of simple distillation.



9. Compare evaporation, crystallization and distillation. In which situation, would you prefer each of these over the others?

Ans :

Comparison:

1. Evaporation involves heating a solution to vaporize the volatile solvent, leaving behind a non-volatile solid residue.
2. Crystallization involves slowly cooling a hot, saturated solution so that the solid solute separates out as pure, regular geometric crystals.
3. Distillation involves heating a liquid mixture until the component with the lower boiling point vaporizes, then routing that vapour through a condenser to cool it back into a liquid state for collection.

Situations for preference:

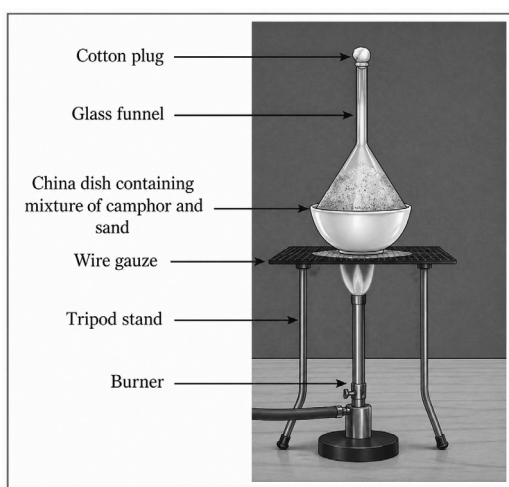
1. Evaporation is preferred when you only need to recover a simple, heat-stable solid solute from a solution and do not care about capturing the solvent that evaporates away.
 2. Crystallization is preferred over evaporation when obtaining a highly pure solid is necessary, especially if the solid might decompose upon dry heating (like sugar) or if soluble impurities need to be left behind in the remaining liquid.
 3. Distillation is preferred when you need to separate and recover both the liquid solvent and the solid solute, or when you need to separate two miscible liquids that have a sufficient difference in their boiling points (at least 25°C).
10. Blood is an example of a colloidal mixture. (i) What would happen if blood behaved like a true suspension inside the body? (ii) In a blood sample, identify the dispersed phase and the dispersion medium.

Ans :

- (i) If blood were a true suspension, the heavier blood cells would settle out of the liquid due to gravity whenever blood flow slowed or stopped. This would lead to blockages in blood vessels, prevent oxygen and nutrients from reaching tissues, and ultimately cause the circulatory system to fail.
- (ii) In a blood sample, the dispersed phase consists of the blood cells (such as red blood cells, white blood cells, and platelets), and the dispersion medium is the liquid plasma in which they are suspended.

Both the assertion and the reason are absolutely true, and the reason perfectly explains the assertion. Rapid cooling forces sudden precipitation, yielding tiny, imperfect crystals. In contrast, slow cooling provides the necessary time for solute particles to arrange themselves neatly into large, perfectly shaped geometric lattices, ensuring excellent crystal growth and high purity.

20. The experimental setup shows the separation of a mixture containing camphor and sand. What physical transformation is represented by the solid deposits forming directly on the inner walls of the inverted funnel?



- (A) Condensation of hot vapours into a liquid before freezing.
 (B) Deposition of vapours directly into a solid state.
 (C) Evaporation of volatile sand particles from the heated dish.
 (D) Crystallization of a solute from a saturated heated solution.

Ans : (B)

Camphor is a sublimable substance that transitions directly from a solid to a vapour upon heating, leaving the non-sublimable sand behind. When these hot vapours touch the cooler inner walls of the funnel, they transform directly back into a solid without passing through a liquid phase, a specific process termed deposition.

21. Why is crystallization generally considered a better technique than simple evaporation to dryness for obtaining pure solid substances from solutions?

- (A) Crystallization is much faster and requires significantly higher temperatures.
 (B) Evaporation removes the solvent completely but leaves behind all the soluble impurities with the solid.
 (C) Evaporation causes the solid to sublime directly into a gas without forming a liquid phase.
 (D) Crystallization completely changes the chemical composition of the substance being separated.

Ans : (B)

Crystallization is vastly superior to simple evaporation because it specifically isolates the pure solid while leaving soluble impurities behind in the remaining liquid. During complete evaporation to dryness, these unwanted impurities are forced to deposit along with the desired solid product, leading to significant contamination and a much lower overall purity of the sample.

22. A chemist studies the effect of temperature on the solubility of three different salts in water. Saturated solutions of each salt are prepared in 100 g of water at 60 °C and then rapidly cooled to 20 °C. Based on the table, which salt will deposit the maximum mass of solid crystals during this cooling process?

Salt Type	Solubility at 20 °C (g/100 g water)	Solubility at 40 °C (g/100 g water)	Solubility at 60 °C (g/100 g water)
Salt X	32	62	106
Salt Y	36	36.5	37
Salt Z	24	41	55

- (A) Salt X
 (B) Salt Y
 (C) Salt Z
 (D) All salts will deposit equal masses of crystals

Ans : (A)

Cooling a saturated solution forces excess dissolved solute to crystallize. The mass of crystals formed equals the difference in solubility at the higher and lower temperatures. Salt X shows the largest solubility drop from sixty degrees to twenty degrees (seventy-four grams), meaning it will deposit the maximum mass of solid crystals.

Ans :

- (i) The formula is (Mass of Solute/Total Mass of Solution)100.

Student A:

Mass of solution

$$= 20\text{g} + 80\text{g} = 100\text{g}.$$

Concentration

$$= (20/100)100 \\ = 20\% \text{ m/m}.$$

Student B:

Mass of solution

$$= 20\text{g} + 100\text{g} = 120\text{g}.$$

Concentration

$$= (20/120)100 \\ = 16.67\% \text{ m/m}.$$

Student C:

Mass of solution

$$= 30\text{g} + 80\text{g} = 110\text{g}.$$

$$\text{Concentration} = (30/110)100$$

$$= 27.27\% \text{ m/m}.$$

- (ii) Student C's solution is the most concentrated. This is because it has the highest mass percentage (27.27%), meaning it contains the highest proportion of solute relative to the total mass of the solution compared to the mixtures prepared by students A and B.

15. Examine figure .



- (i) Identify the separation technique marked as 'S'.
- (ii) Label the apparatus A, B and C.
- (iii) Which of the following mixtures can be separated by the technique identified above? Use the data given in Table . Mixtures:
- (a) water—acetone
- (b) water—salt

- (c) acetone—alcohol
- (d) sand—salt
- (e) alcohol—chloroform
- (f) alcohol—benzene

Table : Boiling points of some compounds

Solvent	Water	Acetone	Alcohol	Chloroform	Benzene
Temperature (°C)	100°C	56°C	78°C	61°C	80°C

Ans :

- (i) The separation technique marked as 'S' is Distillation.
- (ii) A: Distillation flask
B: Water condenser
C: Water inlet (where cold water enters the condenser jacket)
- (iii) Mixture (a) water-acetone can be separated by this technique. Distillation is effective for separating miscible liquids that have a boiling point difference of at least 25 °C. Using the provided table, the difference between the boiling points of water (100 °C) and acetone (56 °C) is 44 °C, making it suitable for this method, whereas the other liquid-liquid pairs listed have boiling point differences that are too small.

OBJECTIVE QUESTIONS

1. Which of the following best describes a homogeneous mixture?
- (A) A mixture in which the components are unevenly distributed and can be easily distinguished.
- (B) A mixture that has a uniform composition throughout and the components are not visibly distinct.
- (C) A mixture consisting of only one pure substance without any added impurities.
- (D) A mixture where solid particles settle down at the bottom after some time.

Ans : (B)

A homogeneous mixture is defined by its uniform composition throughout its entire volume. In these types of mixtures, individual components completely mix and are never visibly distinct from one another. A classic everyday example is common salt dissolved in water. This solution

11. You are given a mixture of sand, common salt and naphthalene figure. The figure depicts various steps used to separate the components of this mixture. Identify and write down the correct sequence of separation techniques.



Ans :

Based on the visual cues in figure the correct sequence of separation techniques is:

1. Sublimation (heating the mixture with an inverted funnel to separate the sublimable naphthalene).
 2. Filtration (pouring the remaining mixture, after adding water to dissolve the salt, through filter paper to remove the insoluble sand).
 3. Evaporation (heating the collected filtrate in a dish to boil off the water and leave behind the common salt).
12. Why is distillation an effective method for separating a mixture of water and acetone?

Ans :

Distillation is effective because water and acetone are miscible liquids with a large difference in their boiling points. Acetone boils at approximately 56°C , while water boils at 100°C . Because this difference (44°C) is greater than 25°C , the acetone readily vaporizes first upon heating and can be condensed and collected as a pure liquid well before the water begins to vaporize significantly.

13. Answer the following questions with the help of the data given in Table

Table: Solubility of various salts (in g per 100 g of water) at different temperatures

Salts	10°C	20°C	30°C	40°C	60°C	80°C
Potassium nitrate	21	32	45	62	106	167
Sodium chloride	36	36	36.3	36.5	37	37
Potassium chloride	35	35	37.4	40	46	54
Ammonium chloride	24	37	41	41	55	66

- (i) What mass of potassium nitrate would be needed to prepare its saturated solution in 50 g of water at 40°C ?
- (ii) A student makes a saturated solution of potassium chloride in water at 80°C and leaves the solution to cool at room temperature (25°C). What would she observe as the solution cools? Explain.
- (iii) What is the effect of a change in temperature on the solubility of salts? Also, compare the changes in the solubility of the four given salts with increasing temperature from 10°C to 80°C .

Ans :

- (i) According to the table, the solubility of potassium nitrate at 40°C is 62 g per 100 g of water. To prepare a saturated solution in half that amount of water (50 g), you would need half the mass of the salt, which is 31 g of potassium nitrate.
- (ii) She would observe solid crystals forming in the solution. This happens because the solubility of solid salts generally decreases as temperature drops. The water can hold 54 g of potassium chloride at 80°C but only around 36 g at 25°C , forcing the excess dissolved salt to separate out of the solution in crystalline form.
- (iii) Generally, an increase in temperature increases the solubility of solid salts in water. Comparing the given salts from 10°C to 80°C : Potassium nitrate shows a massive increase in solubility (from 21 g to 167 g). Ammonium chloride and Potassium chloride show steady, moderate increases in solubility. Sodium chloride is unique among the four, as its solubility shows almost no change, remaining relatively constant (increasing slightly from 36 g to 37 g).

Three students, A, B and C, are preparing sugar solutions for an experiment:

- Student A dissolves 20 g of sugar in 80 g of water.
 - Student B dissolves 20 g of sugar in 100 g of water.
 - Student C dissolves 30 g of sugar in 80 g of water.
- (i) Calculate the mass percentage (% m/m) concentration of sugar in each student's solution.
 - (ii) Whose solution is the most concentrated? Explain why.

scientifically considered completely homogeneous mixtures.

6. In a mixture of sugar and water, the sugar completely dissolves in the liquid. What are the specific terms used to describe the sugar and the water respectively?
- (A) Sugar is the solvent and water is the solute.
 (B) Sugar is the solute and water is the solvent.
 (C) Both sugar and water are considered solvents.
 (D) Both sugar and water are considered solutes.

Ans : (B)

In any standard solution, the component that gets dissolved is known as the solute, while the substance that does the dissolving is called the solvent. Since sugar is the solid that gets dissolved in the larger quantity of liquid water, sugar is the solute and water acts as the solvent in this specific mixture.

7. A student was provided with three different liquid mixtures and asked to record their physical properties to identify their nature. Based on the observations recorded in the table, determine the correct classification for each mixture.

Mixture	Residue on Filter Paper	Path of Light Visible	Settling of Particles
P	None	No	Do not settle
Q	Present	Yes	Settle at bottom
R	None	Yes	Do not settle

- (A) P is a Suspension, Q is a Solution, R is a Colloid
 (B) P is a Solution, Q is a Colloid, R is a Suspension
 (C) P is a Colloid, Q is a Suspension, R is a Solution
 (D) P is a Solution, Q is a Suspension, R is a Colloid

Ans : (D)

A solution (P) is homogeneous, leaves no residue, and does not scatter light. A suspension (Q) is heterogeneous, leaves residue, and its heavy particles settle down. A colloid (R) passes through filter paper and does not settle, but its particles are large enough to scatter light, exhibiting the Tyndall effect.

8. Why is it essential to mix the exact specified amounts of salt and sugar in a fixed volume of water when preparing an Oral Rehydration Solution (ORS)?
- (A) To ensure the solution turns into a heterogeneous mixture quickly.
 (B) To maintain the precise concentration required for effective medical treatment.
 (C) To increase the boiling point of the water significantly.
 (D) To ensure the solute particles become large enough to scatter light.

Ans : (B)

The precise proportion of solute to solvent is always essential when preparing critical solutions like Oral Rehydration Solution. Altering the required amounts of salt, sugar, or water completely changes the concentration of the solution. An incorrect concentration will not function as an effective ORS and may fail to safely rehydrate a sick patient.

9. If 15 g of common salt is dissolved in 85 g of water, what is the mass by mass percentage of the solution formed?
- (A) 15%
 (B) 17.6%
 (C) 85%
 (D) 10%

Ans : (A)

The mass of the solute is fifteen grams, and the mass of the solvent is eighty-five grams. The total mass of the solution is calculated by adding them together, yielding one hundred grams. Using the standard formula, the mass by mass percentage is fifteen divided by one hundred, multiplied by one hundred, giving fifteen percent.

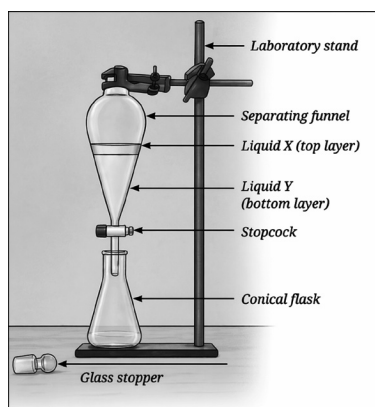
10. A student dissolves 8 g of glucose in water to make 200 mL of a homogeneous solution. Calculate its concentration in mass by volume percentage.
- (A) 4%
 (B) 8%
 (C) 16%
 (D) 25%

Ans : (A)

The mass of the glucose solute is eight grams, and the total volume of the resulting solution is two hundred millilitres. To find the mass by volume percentage, divide the solute mass by the solution volume, and multiply by one hundred.

Eight divided by two hundred, times one hundred, equals exactly four percent.

11. The given apparatus is used to separate a liquid mixture into two distinct layers, labeled Liquid X and Liquid Y. Which fundamental property of the two liquids allows them to be separated using this specific technique?



- (A) A significant difference in their respective boiling points.
 (B) A difference in their solubilities in a common solvent.
 (C) A difference in their densities and their immiscible nature.
 (D) A difference in their rates of evaporation at room temperature.

Ans : (C)

A separating funnel is specifically designed to separate heterogeneous mixtures of immiscible liquids that do not mix. The separation relies entirely on density differences, causing the denser liquid to settle at the bottom while the lighter liquid floats on top, allowing the bottom layer to be carefully drained away through the stopcock.

12. If 5 mL of liquid pesticide is mixed with sufficient water to form 250 mL of pesticide spray, what is its volume by volume percentage?
 (A) 5%
 (B) 2.5%
 (C) 2%
 (D) 1.25%

Ans : (C)

The volume of the liquid pesticide solute is five millilitres, and the total volume of the final solution is two hundred and fifty millilitres. Applying the volume by volume percentage formula involves dividing five by two hundred

and fifty, then multiplying by one hundred. This calculation correctly results in a concentration of exactly two percent.

13. Consider the following Assertion and Reason:
Assertion (A): The solubility of a solid solute in a liquid solvent generally increases with an increase in temperature.
Reason (R): Heating a solution always decreases the spaces between the liquid particles, allowing more solid to dissolve.
 (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

The assertion is entirely correct because heating generally allows a liquid solvent to dissolve more solid solute. However, the reason provided is false. Heating actually increases the kinetic energy of particles and expands the spaces between them, rather than decreasing them. Therefore, the assertion is a true statement while the reason is factually incorrect.

14. Which of the following statements correctly describes a saturated solution?
 (A) A solution in which more solute can be dissolved at a given temperature.
 (B) A solution that cannot dissolve any more solute at a given temperature.
 (C) A solution containing two immiscible liquids mixed thoroughly.
 (D) A solution that has been heated to its boiling point.

Ans : (B)

A saturated solution is strictly defined as a solution that cannot dissolve any additional amount of solute at a specific given temperature. Once this maximum capacity is reached, any extra solid solute added will simply remain undissolved and settle at the bottom of the container, maintaining the equilibrium of the chemical mixture.

15. Consider the following statements regarding the solubility of gases in liquids:
 1. The solubility of gases generally decreases with an increase in temperature.
 2. The solubility of gases generally increases with an increase in temperature.

3. Aquatic animals find it harder to breathe in warm water compared to cold water.
4. Aerated drinks release more fizz when they are kept warm rather than cold.

Which of the statements given above are correct?

- (A) 1, 3 and 4
- (B) 2, 3 and 4
- (C) 1 and 3 only
- (D) 2 and 4 only

Ans : (A)

The solubility of gases in liquid solvents always decreases as the temperature increases. Because warm water holds less dissolved oxygen, aquatic animals struggle to breathe in it. Similarly, warm aerated drinks cannot hold as much carbon dioxide gas, causing them to rapidly release more fizz when opened compared to appropriately chilled beverage bottles.

16. Four students prepared aqueous sugar solutions for a laboratory experiment by mixing different masses of sugar and water. Their measurements are recorded in the table. Which two students successfully prepared solutions having the exact same mass-by-mass percentage concentration?

Student	Mass of Sugar Added (g)	Mass of Water Used (g)
A	10	90
B	20	80
C	15	135
D	25	75

- (A) Student A and Student B
- (B) Student B and Student D
- (C) Student A and Student C
- (D) Student C and Student D

Ans : (C)

Concentration by mass percentage equals the mass of solute divided by the total mass of the solution (solute plus solvent), multiplied by one hundred. Student A's concentration is ten divided by one hundred (ten percent). Student C's concentration is fifteen divided by one hundred and fifty, which precisely equals ten percent.

17. Based on typical solubility curves, what usually happens when a hot, saturated solution of a solid in water is allowed to cool down slowly?
 - (A) The solvent rapidly evaporates into the surrounding air.

- (B) Some of the dissolved solid separates out and forms regular crystals.
- (C) The solution becomes superheated and starts boiling spontaneously.
- (D) The solid particles react with water to form a completely new gas.

Ans : (B)

When a hot, saturated solution cools down, the solubility of the dissolved solid naturally decreases. Because the cooler solvent can no longer hold the same amount of dissolved substance, the excess solute must separate out from the mixture. This excess solid typically precipitates slowly, forming highly organized geometric structures known as pure crystals.

18. In the laboratory process of preparing pure copper sulfate crystals, why is a drop of dilute sulfuric acid added to the water?
 - (A) To increase the boiling point of the water significantly.
 - (B) To give the final crystals a brighter blue colour.
 - (C) To prevent unwanted reactions and help in making pure crystals.
 - (D) To cool down the solution rapidly during the heating process.

Ans : (C)

When preparing copper sulfate crystals in a laboratory setting, adding a small amount of dilute sulfuric acid is a highly crucial step. The acid actively prevents the hydrolysis of copper sulfate and stops unwanted side reactions from occurring. This ensures that the final crystals formed are incredibly pure and possess a well-defined geometric structure.

19. Consider the following Assertion and Reason:

Assertion (A): Rapidly cooling a hot saturated solution in ice-cold water results in smaller and less well-formed crystals.

Reason (R): Slow cooling provides enough time for the particles in the solution to come together in a regular geometric pattern.

 - (A) Both A and R are true and R is the correct explanation of A
 - (B) Both A and R are true but R is not the correct explanation of A
 - (C) A is true but R is false
 - (D) A is false but R is true

Ans : (A)

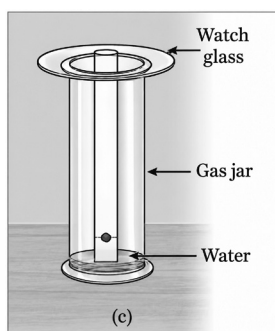
remains homogeneous, and the solute never settles down when left completely undisturbed.

2. When a laser beam is directed through three distinct glass tumblers containing salt water, chalk powder in water, and milk mixed with water, what happens in the salt water?
- (A) The path of the laser beam becomes highly visible.
 (B) The light scatters entirely, making the liquid glow red.
 (C) The path of the laser beam is not visible.
 (D) The light gets completely absorbed by the dissolved salt.

Ans : (C)

Salt water forms a true homogeneous solution where solute particles are extremely small. These dissolved particles are less than one nanometer in diameter, which is too tiny to scatter a passing beam of light. Therefore, when a laser beam passes through salt water, its path remains entirely invisible to the naked human eye.

3. The diagram illustrates a standard laboratory setup for paper chromatography. What is the primary reason the solvent level must be maintained strictly below the initial mixture spot?



- (A) To prevent the mixture components from dissolving directly into the bulk solvent.
 (B) To ensure the paper absorbs moisture from the surrounding air rather than the liquid.
 (C) To allow the mixture to act as the stationary phase during the separation.
 (D) To force the solvent to evaporate before reaching the top of the filter paper.

Ans : (A)

In paper chromatography, the solvent must travel upward through the paper via capillary action to carry and separate the components of the mixture spot. If the solvent level is initially above the spot,

the mixture will simply dissolve outward into the bulk liquid at the bottom, completely preventing any upward chromatographic separation.

4. Consider the following statements regarding mixtures:
1. A well-stirred mixture of sugar and water is a heterogeneous mixture.
 2. Aerated drinks like soda are considered homogeneous mixtures.
 3. A mixture of sand and water has a non-uniform composition.

Which of the above statements is/are correct?

- (A) 1 and 2 only
 (B) 2 and 3 only
 (C) 1 and 3 only
 (D) 1, 2 and 3

Ans : (B)

A well-stirred mixture of sugar and water is a homogeneous mixture, not a heterogeneous one, making the first statement incorrect. Aerated drinks consist of carbon dioxide dissolved uniformly in water, making them homogeneous. A mixture of sand and water is heterogeneous because sand particles do not dissolve, creating a strictly non-uniform composition.

5. Consider the following statements regarding different types of mixtures:
1. A solution of salt in water always remains homogeneous.
 2. A mixture of oil and water is an example of a homogeneous mixture.
 3. Heterogeneous mixtures possess clearly visible and non-uniform compositions.
 4. Brass is an alloy that is scientifically classified as a heterogeneous mixture.

Which of the statements given above are completely correct?

- (A) 1 and 3 only
 (B) 2 and 4 only
 (C) 1, 2 and 3
 (D) 1, 3 and 4

Ans : (A)

The first statement is true because salt completely dissolves to form a uniform solution. The third statement accurately defines heterogeneous mixtures. The second statement is false because oil and water separate into distinct layers, making them strictly heterogeneous. The fourth statement is also false because solid alloys like brass are

- 23.** Arrange the following steps for purifying copper sulfate by crystallization in the correct sequential order:

1. Filter the hot solution to remove insoluble impurities.
2. Gently heat the mixture while stirring constantly.
3. Add copper sulfate to water containing dilute sulfuric acid.
4. Allow the filtered solution to cool slowly without disturbing it.

- (A) 3, 2, 1, 4
(B) 2, 3, 1, 4
(C) 3, 1, 2, 4
(D) 1, 3, 2, 4

Ans : (A)

The correct sequence begins with adding the impure solid to acidic water. Next, the mixture must be heated and stirred to form a highly saturated solution. After heating, the hot solution is quickly filtered to eliminate completely insoluble impurities. Finally, the clear filtrate is allowed to cool slowly, producing pure, well-formed geometric crystals.

- 24.** Which of the following is NOT an example of a naturally occurring crystal?

- (A) Snowflakes formed from freezing water vapour.
(B) Rock salt deposits found in deep underground mines.
(C) Glass used for making regular window panes.
(D) Quartz formations found inside natural caves.

Ans : (C)

Crystals possess a highly regular geometric arrangement of particles. Snowflakes, rock salt, and natural quartz are all classic examples of naturally occurring crystalline solids. However, ordinary window glass is an amorphous solid, meaning its internal particles completely lack a regular, repeating pattern. Therefore, glass is never scientifically classified as a true crystalline substance.

- 25.** Distillation is most suitable for separating a homogeneous mixture of two miscible liquids under which specific condition?

- (A) Both liquids have identical boiling points.
(B) The liquids decompose easily upon heating.
(C) There is a significant difference in their boiling points, typically at least 25 °C.

- (D) Both liquids are completely immiscible and form two distinct layers.

Ans : (C)

Simple distillation is highly effective for separating miscible liquids only when their boiling points differ by at least twenty-five degrees Celsius. This substantial temperature difference allows the more volatile liquid to vaporize entirely before the other liquid begins boiling in significant amounts. The vapour is then condensed and collected cleanly in a separate flask.

- 26.** Match the substances in List-I with their approximate boiling points in List-II based on standard physical data referenced for distillation experiments.

	List-I		List-II
P.	Water	1.	56 °C
Q.	Acetone	2.	61 °C
R.	Alcohol	3.	78 °C
S.	Chloroform	4.	100 °C

- (A) P-4, Q-1, R-3, S-2
(B) P-4, Q-2, R-3, S-1
(C) P-1, Q-4, R-2, S-3
(D) P-3, Q-1, R-4, S-2

Ans : (A)

According to standard laboratory data required for distillation separation, pure water boils at exactly one hundred degrees Celsius. Acetone is highly volatile, boiling at fifty-six degrees. Alcohol typically boils at seventy-eight degrees, while chloroform boils at roughly sixty-one degrees. These specific temperature differences dictate how effectively these liquids can be separated via distillation techniques.

- 27.** Arrange the following events that occur during the simple distillation of an acetone-water mixture in the correct sequential order:

1. Pure liquid acetone is collected securely in a separate receiving flask.
2. The hot vapours pass through the cold water condenser.
3. Acetone reaches its specific boiling point and vaporizes rapidly.
4. The hot gaseous vapours are cooled down and condense back into liquid.

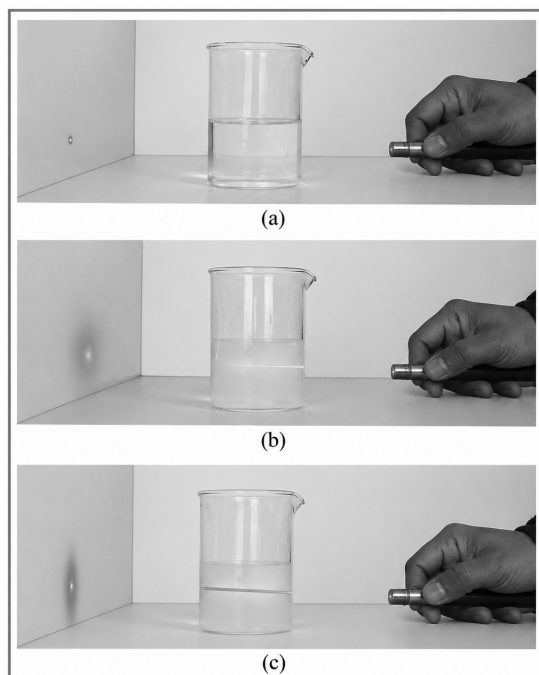
- (A) 3, 2, 4, 1
(B) 2, 3, 1, 4

- (C) 3, 4, 2, 1
(D) 4, 2, 3, 1

Ans : (A)

During simple distillation, the volatile liquid acetone first reaches its boiling point and turns into vapor. These rising hot vapours then enter the cooled water condenser. Inside the condenser, the cold environment forces the hot gas to completely condense back into liquid form. Finally, this purified liquid distillate drips safely into a separate collection flask.

28. A student directs a laser beam through three identical transparent glass beakers containing different mixtures, as shown in setups (a), (b), and (c). The path of the light beam is clearly visible in setup (c). What does this observation indicate about the mixture in beaker (c)?



- (A) It is a true solution where particles completely absorb the laser light.
(B) It contains dispersed particles large enough to scatter the beam of light.
(C) It is a homogeneous mixture with solute particles smaller than 1 nanometer.
(D) It contains a single pure substance that refracts light perfectly.

Ans : (B)

The visibility of the light path is due to the Tyndall effect, which occurs when particles in a mixture are sufficiently large to scatter light.

True solutions have extremely small particles that do not scatter light, indicating that the mixture in beaker (c) is either a colloid or a suspension containing dispersed particles.

29. Which industrial process is fundamentally used to separate crude petroleum oil into various useful fractions such as petrol, kerosene, and diesel?
(A) Simple crystallization
(B) Fractional distillation
(C) Paper chromatography
(D) High-speed centrifugation

Ans : (B)

Crude petroleum is a highly complex mixture containing various hydrocarbon liquids with very small differences in their boiling points. To effectively separate these numerous components, industrial petroleum refineries utilize a sophisticated process known as fractional distillation. This advanced method expertly separates fractions like petrol and diesel based on their slightly differing vaporization temperatures.

30. Consider the following Assertion and Reason:
Assertion (A): Fractional distillation is used to separate miscible liquids when the difference in their boiling points is less than 25 °C.
Reason (R): The fractionating column provides a large surface area for hot vapours to cool and condense repeatedly.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The assertion is accurate because fractional distillation is specifically designed for liquid mixtures with close boiling points. The reason perfectly explains this mechanism. A fractionating column, often packed with glass beads, provides extensive surface area. This allows multiple, repeated condensation and vaporization cycles, ensuring that only the most volatile pure liquid reaches the top.

31. What is the basic scientific principle behind the separation of ink components using paper chromatography?
(A) Differences in the boiling points of the various ink pigments.

- (B) Differences in the physical sizes of the pigment particles under a microscope.
- (C) Differences in the interactions of the components with the solvent and the paper as they travel.
- (D) Differences in the magnetic properties of the colourful ink components.

Ans : (C)

Paper chromatography relies strictly on how different mixture components interact with both the stationary phase and the mobile phase. As the liquid solvent moves upward through the paper via capillary action, it uniquely carries various substances along with it. Components that are more soluble in the solvent travel much faster and separate clearly.

- 32.** A laboratory technician needs to select appropriate separation techniques for four different unknown liquid mixtures. The physical properties of these liquid mixtures are recorded in the table. Which mixture is most suitable to be separated using a simple distillation apparatus?

Mixture Label	Nature of Liquids	Boiling Point of Component 1 (°C)	Boiling Point of Component 2 (°C)
M1	Immiscible	100	80
M2	Miscible	56	100
M3	Miscible	78	80
M4	Immiscible	60	90

- (A) M1, because the liquids have a significant difference in their respective boiling points.
- (B) M2, because the liquids are miscible and possess a boiling point difference greater than 25 °C.
- (C) M3, because the liquids are miscible and have closely related boiling points.
- (D) M4, because the liquids are immiscible and will naturally form two distinct layers.

Ans : (B)

Simple distillation strictly requires the liquid components to be entirely miscible and possess a boiling point difference of at least twenty-five degrees Celsius. Mixture M2 meets both conditions perfectly. Immiscible liquids require a separating funnel. Mixture M3 requires fractional distillation due to its extremely narrow two-degree boiling point difference.

- 33.** Consider the following statements regarding paper chromatography:

1. It is used to separate coloured pigments present in flower petals.
2. The initial solvent level in the beaker must strictly be above the ink spot on the paper.
3. The word 'chromatography' originates from a Greek word meaning colour.

Which of the statements given above are correct?

- (A) 1 and 2 only
- (B) 2 and 3 only
- (C) 1 and 3 only
- (D) 1, 2 and 3

Ans : (C)

The first and third statements are correct; chromatography effectively separates floral pigments and derives its name from chroma, meaning colour. However, the second statement is entirely false. If the initial solvent level sits above the ink spot, the ink will simply dissolve into the bulk liquid rather than migrating upwards along the paper strip.

- 34.** When mustard oil and water are mixed thoroughly in a container and allowed to stand undisturbed, they quickly form two completely distinct layers. This type of mixture involves liquids that are described as:

- (A) Miscible liquids
- (B) Immiscible liquids
- (C) Saturated liquids
- (D) Colloid liquids

Ans : (B)

Liquids that completely fail to mix together and naturally separate into distinct layers when left undisturbed are termed immiscible liquids. Mustard oil and water perfectly demonstrate this behavior because they possess different molecular polarities. Due to this chemical incompatibility, they refuse to form a uniform solution, resulting in a classic heterogeneous physical mixture.

- 35.** When separating a mixture of mustard oil and water using a separating funnel, which distinct layer forms at the bottom and why?

- (A) The oil layer forms at the bottom because it has a higher density than water.
- (B) The water layer forms at the bottom because it has a higher density than the oil.
- (C) The oil layer forms at the bottom because it possesses a lower density than water.

Ans : (A)

To properly form a stable emulsion, one must first combine the immiscible oil and water. Next, carefully add liquid soap, which acts powerfully as an essential emulsifying agent. Then, shake the mixture vigorously to physically disperse the small oil droplets. Finally, you can observe the stable, thoroughly mixed emulsion that refuses to separate immediately.

60. Milk and vanishing creams are classic examples of which specific type of emulsion?

(A) Water-in-oil emulsions
(B) Oil-in-water emulsions
(C) Solid-in-gas emulsions
(D) Gas-in-liquid emulsions

Ans : (B)

Emulsions are unique colloids containing purely liquid phases. In milk and vanishing creams, tiny microscopic droplets of liquid fat or oil represent the dispersed phase, while a larger volume of liquid water forms the continuous dispersion medium. This specific arrangement perfectly classifies them as classic oil-in-water emulsions, distinguishing them entirely from heavy butter or lotions.

61. What crucial role do proteins play in natural milk to prevent it from separating quickly into distinct layers of fat and water?

(A) They act as powerful catalysts to boil the water faster.
(B) They actively act as stabilizing emulsifying agents.
(C) They cause rapid coagulation of all the fat particles.
(D) They force the milk to undergo complete sublimation at room temperature.

Ans : (B)

Oil and water naturally repel each other and tend to separate. However, in fresh milk, complex natural proteins perfectly act as highly effective emulsifying agents. These proteins actively coat the tiny suspended fat droplets, preventing them from clumping together. This essential stabilization perfectly maintains the uniform, creamy colloidal structure of the milk over time.

62. Consider the following statements summarizing the properties of different types of mixtures:

1. True solutions are strictly homogeneous and never scatter light.

2. Suspensions are completely transparent and cannot be separated by simple filtration.
3. Colloids appear homogeneous but are actually heterogeneous at a microscopic level.

Which of the statements given above are correct?

(A) 1 and 2 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

Ans : (B)

The first statement is correct; true solutions possess incredibly small particles that cannot scatter light. The third statement is also highly accurate; colloids visually look uniform but contain microscopic heterogeneous suspended particles. However, the second statement is entirely false because heavy suspensions are cloudy, strictly heterogeneous, and can be easily separated using basic filter paper.

63. A dry mixture contains fine sand, common salt, and crushed naphthalene. Which logical sequence of techniques should be used to completely separate all three components?

1. Filter the resulting mixture to separate the insoluble sand.
2. Heat the dry mixture carefully to sublime and collect the naphthalene.
3. Evaporate the clear filtrate to completely recover the pure common salt.
4. Add excess liquid water to the remaining mixture and stir thoroughly.

(A) 4, 1, 3, 2
(B) 2, 4, 1, 3
(C) 2, 1, 4, 3
(D) 1, 4, 2, 3

Ans : (B)

First, gently heat the dry mixture so the naphthalene undergoes complete sublimation and is cleanly removed. Next, add water to dissolve the soluble salt while leaving the sand completely unaffected. Then, filter the wet mixture to physically isolate the insoluble sand residue. Finally, safely evaporate the remaining salty filtrate to recover pure solid salt crystals.

64. In modern sewage treatment plants, what specific technique is typically used to force tiny, stubborn waste particles to rapidly clump together and settle down before releasing the water?

(A) Fractional distillation
(B) Sublimation

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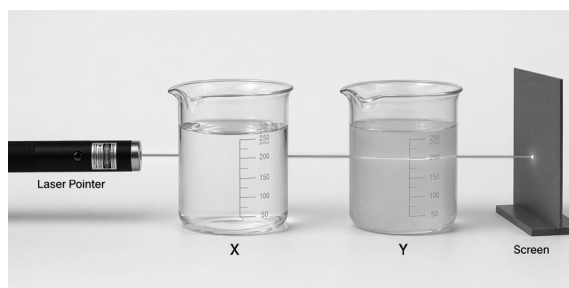
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- (C) Deposition
(D) Solidification

Ans : (C)

The direct phase transition from a gaseous vapor back to a solid state, entirely bypassing the liquid phase, is scientifically termed deposition. It is exactly the reverse physical process of sublimation. A common everyday example of deposition is the sudden formation of solid frost on extremely cold window panes during harsh winter nights.

40. Based on the interaction of the laser beam with the liquids in beakers X and Y, which of the following correctly identifies the nature of the two mixtures?



- (A) X is a colloid and Y is a true solution.
(B) X is a true solution and Y is a suspension where particles have settled.
(C) X is a true solution and Y is a colloid.
(D) X is a suspension and Y is a homogeneous mixture.

Ans : (C)

Beaker X represents a true solution because its particles are too small to scatter light, keeping the beam invisible. Beaker Y represents a colloid; its larger dispersed particles scatter the laser light, making the beam's path clearly visible. This phenomenon is called the Tyndall effect. Other options incorrectly assign these scattering properties.

41. Alloys are uniform mixtures of two or more metals, or a metal and a non-metal. Why are they generally classified as homogeneous mixtures despite physical methods being unable to separate their components?
- (A) They show the distinct properties of their individual constituents and can have variable compositions.
(B) They can only be formed by chemically reacting non-metals together at high temperatures.

- (C) They always form distinct visible layers when cooled very slowly.
(D) They scatter laser light heavily, proving they consist of extremely large suspended particles.

Ans : (A)

Although physical laboratory methods cannot separate an alloy's components, alloys are still considered mixtures because they retain and exhibit the chemical properties of their individual constituents. Furthermore, their elemental composition can be slightly varied. For instance, brass is a homogeneous mixture precisely because it blends roughly eighty percent copper and twenty percent zinc uniformly.

42. Match the common alloys in List-I with their approximate elemental composition in List-II.

	List-I		List-II
P.	Brass	1.	Iron mixed with carbon, chromium, nickel and molybdenum
Q.	Bronze	2.	80% copper and 20% zinc
R.	Stainless steel	3.	80% copper and 20% tin
S.	Solid alloy physical state	4.	Uniformly mixed metallic homogeneous mixture

- (A) P-2, Q-3, R-1, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-1, R-3, S-4
(D) P-1, Q-2, R-3, S-4

Ans : (A)

Brass is a widely used solid alloy consisting of roughly eighty percent copper and precisely twenty percent zinc. Bronze comprises approximately eighty percent copper mixed with twenty percent tin. Stainless steel combines iron with carbon, chromium, nickel, and molybdenum. Finally, all standard solid alloys are technically classified perfectly as uniformly mixed homogeneous mixtures.

43. A heterogeneous mixture in which the solid particles do not dissolve but remain suspended throughout the bulk of the medium is called a suspension. Which of the following is a key characteristic of the particles in a suspension?
- (A) They are smaller than 1 nanometer in diameter and invisible to the naked eye.

- (B) They are larger than 1000 nanometers and can easily be seen by the naked eye.
 (C) They never settle down at the bottom, regardless of how long the mixture is left undisturbed.
 (D) They cannot be separated from the liquid medium using basic filter paper.

Ans : (B)

A true suspension is heavily characterized by its massive particle size. These suspended solid particles are significantly larger than one thousand nanometers in diameter, making them easily visible to the naked human eye. Because of their substantial mass, these large particles will naturally settle down at the bottom due to gravity if left entirely undisturbed.

44. A student examines three separate mixtures and records the critical physical properties of their components in a table. The student must assign a specific separation technique to each mixture based on these defining properties. Identify the correct sequence of separation methods.

Mixture	Property of Component A	Property of Component B
Mixture I	Volatile solid capable of turning directly to gas	Non-volatile solid impurity
Mixture II	Soluble pigment in a liquid solvent	Another pigment with different solubility in the same solvent
Mixture III	Heavier solid particles	Lighter liquid dispersion medium

- (A) Centrifugation, Paper Chromatography, Sublimation
 (B) Sublimation, Paper Chromatography, Centrifugation
 (C) Distillation, Centrifugation, Sublimation
 (D) Paper Chromatography, Sublimation, Distillation

Ans : (B)

Mixture I contains a sublimable solid, making sublimation the ideal separation method. Mixture II relies on differential solubility rates in a moving solvent, which fundamentally defines paper chromatography. Mixture III consists of heavier solid particles suspended in liquid, which are

forced outward and separated effectively utilizing rapid, high-speed centrifugation.

45. Consider the following Assertion and Reason:

Assertion (A): When muddy water is left undisturbed for a long time, the heavier mud particles settle at the bottom.

Reason (R): The solid particles in a suspension are large enough to be pulled downward by the force of gravity over time.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

Both statements are absolutely correct, and the reason accurately explains the physical assertion. Muddy water perfectly exemplifies a standard suspension. The large, heavy mud particles suspended in the liquid possess significant mass. Consequently, when the fluid is left perfectly still, earth's gravity steadily pulls these dense particles downward, causing them to settle completely.

46. What is the fundamental principle used to separate components in a high-speed centrifugation machine?

- (A) Lighter particles are forced to the bottom while heavier particles stay at the top.
 (B) Centrifugal force causes heavier particles to move outwards and settle at the bottom while lighter liquid remains at the top.
 (C) The machine heats the mixture rapidly, boiling away all the lighter liquid components.
 (D) It employs strong magnetic fields to strictly pull heavier particles downward.

Ans : (B)

Centrifugation actively relies on incredibly rapid spinning to generate powerful outward centrifugal force. This intense physical force heavily acts upon the mixture's components. It aggressively pushes the denser, heavier particles outward and downward to the bottom of the tube, while the much lighter liquid component remains floating securely at the very top.

47. Which of the following medical procedures heavily relies on the scientific process of centrifugation?

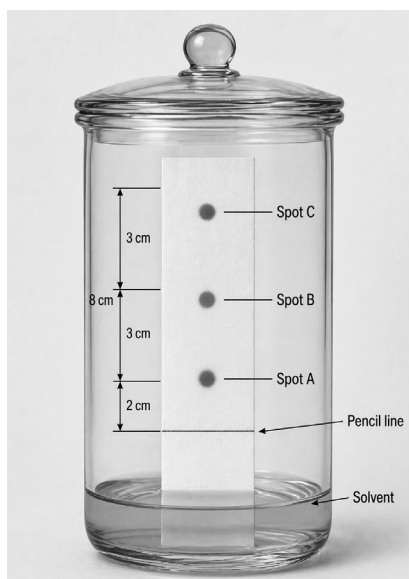
- (A) Separating red blood cells from plasma in a donated blood sample.

- (B) Removing large undissolved chalk particles from a simple water mixture.
- (C) Extracting pure essential oils from freshly picked flower petals.
- (D) Separating a mixture of finely crushed camphor and common sea salt.

Ans : (A)

Centrifugation is widely utilized in medical laboratories to separate complex biological mixtures. By spinning small tubes at tremendously high speeds, laboratories can efficiently separate heavy red blood cells from the lighter liquid plasma. This critical separation is essential for performing accurate blood tests and preparing life-saving blood transfusions for hospital patients.

- 48.** The paper chromatogram shows the separation of a black ink sample. Based on the position of the separated spots A, B, and C, what can be concluded about their physical properties?



- (A) Component C is the most soluble in the solvent.
- (B) Component A is the most soluble in the solvent.
- (C) Component B evaporates faster than component A.
- (D) Component C is the most dense and therefore rises highest.

Ans : (A)

In paper chromatography, separation occurs based on the difference in solubility of the components in the moving solvent. The component that is most soluble in the liquid solvent dissolves easier and

travels faster and higher up the paper. Therefore, component C, being at the highest position, is the most soluble, rendering the other statements false.

- 49.** When powdered alum (fitkari) is added to a beaker containing cloudy muddy water, the fine suspended impurities clump together and settle down rapidly. What is this specific chemical process called?
- (A) Sublimation
 - (B) Fractional distillation
 - (C) Coagulation
 - (D) Crystallization

Ans : (C)

The precise process of adding a special substance to force fine suspended particles to clump together is called coagulation. Powdered alum acts incredibly well as a chemical coagulant. It actively causes tiny, stubbornly suspended mud particles to bind into much larger, heavier clumps, which then quickly settle down under the simple influence of gravity.

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- 50.** Consider the following statements regarding the process of coagulation:
1. Alum is often used as a chemical coagulant in basic water purification processes.
 2. The formation of paneer (cheese) from hot milk involves coagulation.
 3. Lemon juice or vinegar can actively act as coagulants for milk proteins.
 4. Coagulation always requires the mixture to be heated to exactly 100 °C.

Which of the statements given above are correct?

- (A) 1, 2 and 3
- (B) 2, 3 and 4
- (C) 1, 3 and 4
- (D) 1 and 2 only

Ans : (A)

The first three statements accurately describe coagulation. Alum expertly purifies water by clumping dirt, while acidic substances like lemon juice easily coagulate milk proteins to form paneer. However, the fourth statement is completely false. While gentle heating can sometimes assist the process, coagulation absolutely does not require a strict boiling temperature of one hundred degrees.

76. Under what condition is fractional distillation utilized instead of simple distillation?

Ans :

Fractional distillation is efficiently utilized when the two miscible liquids within a mixture have a relatively small difference in their specific boiling points.

77. How is fractional distillation used in a petroleum refinery?

Ans :

In a petroleum refinery, crude oil is processed and separated into various useful fractions like petrol and diesel based on small boiling point differences.

78. What causes different ink colours to separate during paper chromatography?

Ans :

Separation occurs because different components in the ink move at different speeds depending on their specific interactions with the solvent and the paper strip.

79. Where does the actual separation of substances take place in paper chromatography?

Ans :

The actual separation of substances takes place directly on the special chromatographic paper as the liquid solvent gradually rises through it carrying the components.

80. What is the literal meaning of the word chromatography?

Ans :

The word chromatography originates from the Greek words chroma, meaning colour, and graphein, meaning to write, essentially translating to writing with colour.

81. Which laboratory instrument is specifically used to separate two immiscible liquids like oil and water?

Ans :

A separating funnel is specifically utilized to cleanly separate two immiscible liquids based on the distinctive differences in their individual respective density values.

82. Why does mustard oil form the upper layer when mixed with water in a separating funnel?

Ans :

Mustard oil readily forms the upper layer simply because it is significantly less dense than water, causing it to naturally float on top.

83. What is the scientific term for the process where a solid directly changes to vapour?

Ans :

The scientific term for the transition of a solid directly into a vapour without passing through the intermediate liquid state is known as sublimation.

84. State one similarity between camphor and dry ice upon heating.

Ans :

Both camphor and solid carbon dioxide, known as dry ice, naturally undergo sublimation and change directly into gas without becoming liquid first.

85. What is an alloy composed of?

Ans :

An alloy is composed of a homogeneous mixture containing two or more metals, or a metal combined with a non-metal, mixed at high temperatures.

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86. Describe the nature of a suspension in one clear sentence.

Ans :

A suspension is a heterogeneous mixture where relatively large solid particles do not dissolve but remain entirely suspended throughout the bulk of the medium.

87. What is the basic principle behind the process of centrifugation?

Ans :

Centrifugation uses rapid spinning to create an outward centrifugal force, causing heavier particles to settle downwards while lighter liquid components easily remain at the top.

55. What specific optical phenomenon occurs when a fine beam of light passes through a colloidal mixture in a dark room, making the path of the light clearly visible?

(A) Total internal reflection of light
(B) Refraction of light
(C) Tyndall effect
(D) Sublimation of light particles

Ans : (C)

The intense scattering of a light beam by intermediate-sized particles within a mixture is famously known as the Tyndall effect. When a laser beam travels through a dense colloid like milk, the suspended particles are just large enough to actively bounce the light rays in multiple directions, rendering the entire beam highly visible to observers.

56. The setup shows the distillation of a mixture of water (boiling point 100°C) and acetone (boiling point 56°C). At the specific moment captured in the diagram, what is the primary composition of the substance passing through the water condenser?



- (A) Vapours of pure water
(B) Vapours of pure acetone
(C) A mixture of water and acetone vapours in equal proportion
(D) Liquid water that has cooled down

Ans : (B)

Distillation separates miscible liquids based on boiling point differences. Since the thermometer reads 56°C , the temperature corresponds to the boiling point of acetone. Therefore, acetone is actively vaporizing. These acetone vapours pass into the condenser, where they cool and condense. Water remains in the boiling flask because its boiling point is much higher.

57. Which of the following everyday scenarios is a direct practical example of the Tyndall effect?

(A) Sugar crystals completely dissolving into a hot cup of tea.
(B) Bright sunlight passing through small gaps in the leaves of a dense forest canopy.
(C) Water rapidly boiling and turning into invisible hot steam.
(D) Salt actively precipitating out of a highly saturated seawater solution.

Ans : (B)

The Tyndall effect is heavily dependent on light scattering. In a dense forest, tiny dust particles and microscopic water droplets suspended in the cool morning air act just like a giant colloidal mixture. These suspended particles actively scatter the bright incoming sunlight, making the majestic distinct rays of light clearly visible beneath the trees.

58. In a colloidal mixture, what specific term is used to describe the solute-like component that is uniformly distributed throughout the mixture?

(A) Dispersion medium
(B) Dispersed phase
(C) Saturated solute
(D) Immiscible fraction

Ans : (B)

A colloidal system consists of two highly distinct parts. The tiny, solute-like particles that are spread out are scientifically termed the dispersed phase. The continuous liquid, solid, or gaseous substance in which these particles are thoroughly suspended is called the dispersion medium. Together, they create the unique optical and physical properties of all colloids.

59. Which is the correct procedural sequence for creating a stable, simple emulsion of cooking oil and water using soap?

1. Thoroughly mix and shake the contents of the container vigorously.
2. Add a few specific drops of liquid cooking oil to a small volume of water.
3. Observe the milky, stabilized emulsion formed due to the emulsifying agent.
4. Add a few measured drops of liquid soap solution to the mixture.

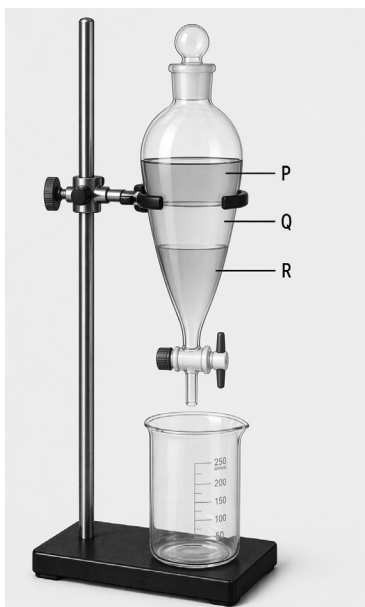
(A) 2, 4, 1, 3
(B) 4, 2, 1, 3
(C) 1, 2, 4, 3
(D) 2, 1, 4, 3

- (D) The water layer forms at the bottom because its boiling point is significantly higher.

Ans : (B)

A separating funnel relies entirely on the contrasting physical densities of immiscible liquids. Because liquid water is significantly denser than mustard oil, it naturally sinks and forms the heavy bottom layer. Consequently, the lighter oil floats on top. The stopcock allows the denser water to be carefully drained away from the lighter oil.

36. A student carefully pours a mixture of three immiscible liquids into the separating funnel as illustrated. If the stopcock is opened, which statement correctly describes the properties and separation order of these liquids?



- (A) Liquid P has the highest density and will be collected first in the beaker.
 (B) Liquid R has the highest density and will be collected first in the beaker.
 (C) Liquid Q has the lowest density and will remain in the funnel last.
 (D) Liquid P has the highest density and will remain in the funnel last.

Ans : (B)

In a mixture of immiscible liquids, the liquid with the highest density settles at the bottom, while the lightest liquid floats at the top. Liquid R forms the bottommost layer, indicating it has the highest density. When the stopcock opens, liquid

R will flow out and be collected first, making other options incorrect.

37. Which of the following correctly describes the physical process of sublimation?

- (A) The transition of a solid substance directly into a gas upon heating, bypassing the liquid state.
 (B) The melting of a solid into a liquid at extremely high temperatures.
 (C) The rapid boiling of a liquid to form dense visible vapours.
 (D) The freezing of water vapour directly into solid ice crystals in winter.

Ans : (A)

Sublimation is the highly specific physical transition where a solid substance changes directly into a vapor state upon heating, completely bypassing the intermediate liquid phase. This unique process is perfectly demonstrated by substances like dry ice, camphor, and naphthalene, which never melt into liquids but transform straight into gas when exposed to heat.

38. In a laboratory activity to separate a mixture of camphor and sand, the mixture is gently heated in a china dish covered with an inverted glass funnel. What happens to the camphor?

- (A) It melts into a liquid and slowly seeps into the sand.
 (B) It sublimates into vapours and condenses as a solid on the cool inner walls of the funnel.
 (C) It reacts strongly with the sand to produce a completely new black compound.
 (D) It dissolves entirely into the moisture present within the surrounding atmospheric air.

Ans : (B)

When the camphor and sand mixture is heated gently, the camphor rapidly undergoes sublimation. It turns directly into hot vapor without ever melting. As these vapours rise and hit the cold inner surface of the inverted glass funnel, they immediately undergo deposition. This causes pure solid camphor to crystallize neatly on the glass.

39. The process wherein hot vapours cool down and change directly back into a solid without ever becoming a liquid is specifically known as:

- (A) Condensation
 (B) Evaporation

- (C) Coagulation
(D) Paper chromatography

Ans : (C)

Modern sewage treatment relies heavily on the vital chemical process of coagulation. By adding specific chemical coagulants to dirty wastewater, tiny, stubborn suspended particles are actively forced to clump together into much larger, heavier aggregates. These large clumps then naturally settle firmly at the bottom, allowing the significantly clearer water to be processed further safely.

VERY SHORT ANSWER

65. What is a homogeneous mixture?

Ans :

A homogeneous mixture is a well-stirred mixture, like sugar and water, that always has a uniform composition throughout its entire given volume.

66. State one difference between a homogeneous and a heterogeneous mixture based on appearance.

Ans :

A homogeneous mixture always has a completely uniform appearance throughout, whereas a heterogeneous mixture has visibly distinct parts and a distinctly non-uniform composition.

67. Give one example of a heterogeneous mixture commonly found in daily life.

Ans :

A stirred mixture of sand and water is a common heterogeneous mixture because the sand particles remain easily visible and settle over time.

68. Define the term concentration of a solution.

Ans :

The concentration of a solution is defined as the exact amount of solute dissolved in a specific given amount of solvent or total solution.

69. Give the formula for calculating the mass by volume percentage of a solution.

Ans :

To calculate mass by volume percentage, you divide the mass of the solute by the volume of the solution and then multiply by hundred.

70. What is the general relationship between temperature and the solubility of a solid solute in a liquid?

Ans :

The solubility of a solid solute in a liquid solvent generally increases as the temperature of the given solution progressively rises during the process.

71. Give one reason why we mention temperature when defining a saturated solution.

Ans :

Temperature is mentioned because the maximum amount of solute that can dissolve in a specific solvent naturally changes as the temperature increases or decreases.

72. What is a saturated solution?

Ans :

A saturated solution is a specific mixture that simply cannot dissolve any more solute at a particular, given temperature under normal laboratory conditions.

73. What is the fundamental principle behind the process of purification by crystallization?

Ans :

Crystallization is entirely based on the significant differences in the solubility of a specific solid substance in a solvent at various different temperatures.

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74. What is the result of cooling a hot, saturated solution of copper sulfate slowly?

Ans :

Cooling it slowly gives the dissolved particles enough time to come together, resulting in the formation of large, shiny, well-shaped, and pure blue crystals.

75. Give one practical application of the simple distillation process.

Ans :

Distillation is practically used to carefully separate a homogeneous mixture of two miscible liquids that have a significant difference in their boiling points.

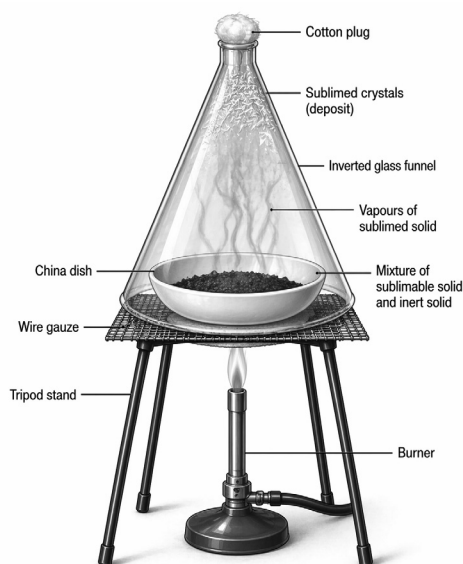
51. Blood cannot be cleanly separated by simple filtration, yet its components can be separated by high-speed centrifugation. Moreover, individual blood cells cannot be seen with the naked eye. Based on these specific properties, blood is best classified scientifically as a:

(A) True homogeneous solution
(B) Colloid
(C) Pure crystalline substance
(D) Simple immiscible mixture

Ans : (B)

Blood is perfectly classified as a colloid. It is entirely neither a true transparent solution nor a standard suspension. Its suspended particles are larger than those found in simple solutions but significantly smaller than those in basic suspensions. Because these particles are minute, they pass through regular filters but can be separated by intense centrifugation.

52. The illustrated apparatus is used to separate a mixture. Based on the physical changes occurring in the setup, which pair of substances is most likely being separated?



(A) Common salt and chalk powder
(B) Camphor and sand
(C) Iron filings and sulfur powder
(D) Copper sulfate and water

Ans : (B)

The diagram illustrates the process of sublimation, where a solid directly converts into vapour upon heating, and then condenses back to a solid on a

cooler surface. Camphor undergoes sublimation, while sand does not. The white deposits are pure camphor. Salt, chalk, iron, sulfur, and copper sulfate do not sublime, making them incorrect.

53. How does the average particle size in a colloidal mixture compare to that in true solutions and suspensions?

(A) Colloidal particles are smaller than 1 nm, just like solutions.
(B) Colloidal particles are larger than 1000 nm, just like suspensions.
(C) Colloidal particles are intermediate in size, typically ranging strictly between 1 nm and 1000 nm in diameter.
(D) Colloidal particles constantly change size depending purely on the room temperature.

Ans : (C)

Particle size perfectly defines mixture categories. True solutions contain incredibly tiny particles smaller than one nanometer. Suspensions contain massive, visible particles larger than one thousand nanometers. Colloids sit exactly in the middle. Their moderately sized particles strictly range between one and one thousand nanometers, keeping them uniformly dispersed without ever naturally settling down.

54. Consider the following Assertion and Reason:

Assertion (A): The particles in a colloidal mixture do not settle down over time when left completely undisturbed.

Reason (R): Colloidal particles are uniformly dispersed and are small enough to remain continuously suspended by molecular collisions in the medium.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Both statements are absolutely true, and the reason beautifully explains the assertion. Unlike heavy suspensions, colloidal particles fall neatly within the intermediate one to one thousand nanometer range. This specific moderate size allows them to be continuously knocked around by the surrounding solvent molecules, effectively preventing them from ever settling firmly at the bottom.

88. Under what condition is coagulation practically used in daily life?

Ans :

Coagulation is frequently used during water purification to successfully make very fine suspended muddy impurities clump together and settle down for easier removal.

89. What is the specific function of adding alum to muddy water?

Ans :

Alum functions as a reliable coagulant that effectively causes the fine suspended mud particles to quickly clump together into much larger, heavier solid aggregates.

90. State one difference between a suspension and a true solution based on particle size.

Ans :

Particles in a true solution are extremely tiny, under one nanometer, while a suspension contains much larger visible particles exceeding one thousand nanometers.

91. What is the dispersed phase in a colloidal mixture?

Ans :

The dispersed phase in a colloidal mixture refers to the solute-like component consisting of the specific particles that are suspended throughout the dispersion medium.

92. Why does a beam of light become visible when passing through a colloid?

Ans :

A light beam becomes highly visible because the relatively large particles present within the colloid effectively scatter the incoming light in all different directions.

93. Who scientifically studied and explained the scattering of light by particles?

Ans :

The scattering of light by suspended particles was first studied and successfully explained by the prominent scientist John Tyndall, hence named the Tyndall effect.

94. Give one example of an emulsion used in our daily lives.

Ans :

Milk is a very common daily life example of an emulsion where both the dispersed phase and the surrounding dispersion medium are liquid states.

SHORT ANSWER QUESTIONS

95. Explain the Tyndall effect. Why is it visually observed in a mixture of milk and water but never in a simple mixture of common salt and water?

Ans :

The Tyndall effect is the optical scattering of a beam of light by suspended microscopic particles in a mixture, essentially making the straight path of the light beam clearly visible. Milk mixed with water forms a heterogeneous colloidal emulsion, which contains large dispersed fat particles (between 1 nm and 1000 nm) that successfully scatter incoming light. Conversely, salt dissolved in water forms a true homogeneous solution. The completely dissolved salt particles are incredibly tiny, measuring less than 1 nm, which is far too small to scatter light.

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96. What exactly is a homogeneous mixture? How does it fundamentally differ from a heterogeneous mixture with respect to physical composition and visible boundaries?

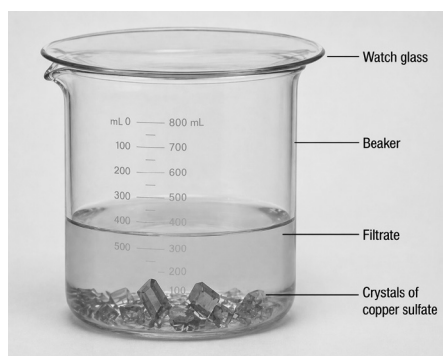
Ans :

A homogeneous mixture is a perfectly uniform mixture that has a consistent chemical composition scattered equally throughout its entire mass, meaning its dissolved components are thoroughly mixed together. A standard example is sugary water. It differs greatly from a heterogeneous mixture primarily in structure and particle visibility. In a heterogeneous mixture like muddy water, the overall composition is completely non-uniform. The individual raw components or solid particles remain distinctly visible to the human eye, often creating clearly identifiable physical boundary layers within the containing vessel.

127. (a) Explain the entire process of obtaining pure copper sulfate crystals from an impure laboratory sample, accompanied by a diagram showing the cooling phase of the hot saturated solution?
- (b) Why is crystallization considered a significantly better technique than simple evaporation to dryness for purifying such solid mixtures?

Ans :

(a)



To obtain pure copper sulfate, dissolve the impure sample in a minimum amount of water with a drop of dilute sulfuric acid. Heat the mixture gently to prepare a saturated solution. Filter this hot liquid to remove insoluble impurities. Finally, allow the clear filtrate to cool slowly without disturbance. As the temperature drops, solubility decreases, and pure copper sulfate particles arrange into geometric solid crystals, leaving soluble impurities behind in the remaining liquid.

- (b) Crystallization is vastly superior to simple evaporation to dryness for two main reasons. Firstly, direct heating during evaporation can cause certain sensitive solids to decompose or char completely. Secondly, evaporation leaves all soluble impurities mixed directly with the newly dried solid. Crystallization successfully isolates the pure compound because the soluble impurities remain fully dissolved within the leftover solvent instead of incorporating into the newly formed solid crystal lattice.
128. (a) Describe a detailed activity using paper chromatography to definitively show that black sketch pen ink is not a single individual colour?

- (b) State the fundamental basic principle of separation utilised in this specific technique?
- (c) Will the separation pattern remain exactly the same if liquid alcohol is used as a solvent instead of water?

Ans :

- (a) To prove black ink is a mixture, draw a horizontal pencil line near the bottom of a filter paper strip and place a small spot of black ink precisely on its centre. Suspend this paper strip vertically inside a glass jar containing a small amount of water, ensuring the water level remains just below the ink spot. As the water slowly rises up the paper via capillary action, it carries the ink dyes along with it, separating into multiple distinct coloured bands.
- (b) This technique relies on the principle that different components of a mixture possess different solubilities in a given solvent and interact differently with the stationary paper. Consequently, they travel upward at varying speeds.
- (c) If alcohol is substituted for water, the separation pattern will change significantly because dye solubilities will differ entirely in the new solvent.

129. (a) Define the specific terms sublimation and deposition as they relate to changes in states of matter?
- (b) You are given a complex mixture of camphor, sand, and common salt. Propose a logical, sequential methodology to separate these three distinct components completely from one another?

Ans :

- (a) Sublimation is the unique physical process where a solid changes directly into a vapour upon heating, completely bypassing the liquid state. Deposition is the exact reverse process, where a vapour cools and transforms directly back into a solid without becoming a liquid.
- (b) To separate the given mixture, follow a sequential physical methodology. First, gently heat the entire mixture in a china dish covered with an inverted funnel. The camphor will undergo sublimation and deposit onto the cool inner walls of the funnel, separating it entirely. Second, add water to the remaining

101. Describe exactly how the technique of paper chromatography is efficiently utilized in a chemistry laboratory to safely separate the distinctly different coloured chemical dyes currently present in a single black ink spot.

Ans :

Paper chromatography efficiently separates mixed chemical components strictly based upon their distinctly different natural rates of physical movement along a highly porous paper surface. A tiny spot of black ink is gently placed near the absolute bottom edge of a filter paper strip. This paper is subsequently dipped partially into a liquid solvent like water. As the liquid slowly rises upward through the paper fibres via natural capillary action, it actively carries the dissolved dye molecules. The highly soluble dyes travel much faster, successfully separating the distinct colours vertically.

102. Draw a simple mechanical diagram properly illustrating the industrial process of active centrifugation. Explain clearly how this unique rapid technique successfully separates heavy solid microscopic particles from a large liquid mixture.

Ans :



Industrial centrifugation involves forcefully spinning a fluid mixture rapidly inside a closed tube at incredibly high speeds. When this sealed tube constantly rotates in a violent circular motion, a massive outward centrifugal force strongly acts upon the fluid contents. This intense physical force rapidly pushes the much denser, substantially heavier solid particles outward, mechanically forcing them to rapidly clump and settle down at the extreme bottom of the spinning tube. The much lighter liquid portion safely

remains at the absolute top, ensuring a perfectly clean fluid separation.

103. A student confidently asserts that a standard metal alloy like typical brass is actually a strict chemical compound because it firmly exists as a single uniform solid material. Do you agree? Justify your stance.

Ans :

I completely disagree with the student's confident assertion because a metal alloy is absolutely classified as a perfectly homogeneous chemical mixture, never a strict compound. Although solid brass visually appears to be a single uniform metallic material, it actually retains the fundamental chemical properties of its original raw constituent metals, namely copper and zinc. Furthermore, the overall fractional composition of any manufactured alloy can easily vary, whereas a true chemical compound always possesses a rigidly fixed mass ratio of totally bonded elements that cannot simply change.

104. What is a saturated solution? Describe the sequential experimental steps you would carefully follow to successfully prepare perfectly pure blue copper sulfate crystals starting from an impure solid powder sample.

Ans :

A saturated solution is an intensely concentrated chemical solution that fundamentally cannot dissolve any additional solid solute at its current specific temperature. To manually prepare pure crystals, first dissolve the impure copper sulfate powder in a minimal volume of warm water mixed with dilute sulfuric acid. Vigorously heat and stir this mixture rapidly in a water bath until completely saturated. Next, carefully filter this boiling hot liquid to trap any large insoluble impurities. Finally, permit the perfectly clear hot filtrate to cool incredibly slowly entirely undisturbed at room temperature.

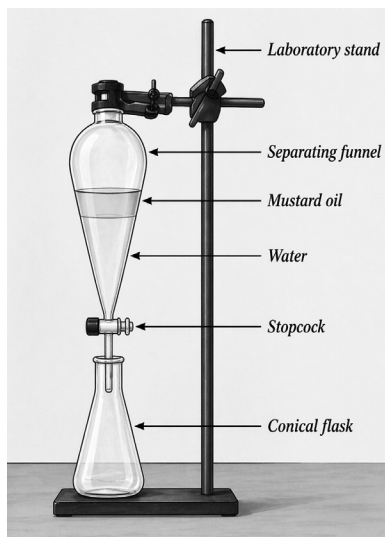
105. Explain the chemical process of water coagulation utilized in modern purification plants. Exactly how does adding powdered crystalline alum significantly help in rapidly cleaning highly polluted, heavily muddy river water?

Ans :

Chemical coagulation is a highly vital separation process that involves deliberately introducing a

97. Draw a labelled diagram of the standard laboratory setup used to physically separate a mixture of mustard oil and water. Briefly explain the scientific principle behind this technique.

Ans :



This separation method heavily relies upon the scientific principle of varying physical densities between two immiscible liquids. Since raw mustard oil and pure water naturally refuse to mix, they spontaneously form two distinctly separate horizontal layers when left completely undisturbed. Because liquid water is substantially heavier and possesses a higher density, it completely settles at the very bottom. By simply opening the stopcock, the denser water layer easily drains out, leaving the lighter oil trapped inside the funnel.

98. Define the related processes of sublimation and deposition. Provide one clear example of a solid heterogeneous mixture that can be quickly separated by directly exploiting this unique property.

Ans :

Sublimation is the highly fascinating physical process where a solid completely changes directly into a hot gaseous state upon active heating, entirely bypassing the usual intermediate liquid phase. Conversely, deposition is the exact reverse transition where a cooling gas rapidly transforms directly back into a cold solid without ever becoming liquid. A perfect daily example of a mixture safely separated using this thermal property is crushed camphor heavily mixed with

normal sand. When gently heated, only the camphor rapidly sublimates, effectively leaving the non-sublimable sand completely behind.

99. Explain in detailed scientific terms why the process of crystallization is widely considered a significantly better technique for purifying solid chemical substances compared to the simple boiling evaporation method.

Ans :

Crystallization is vastly superior to the simple evaporation technique because it consistently yields a substantially purer final solid product. During aggressive evaporation, a liquid solution is heated completely to absolute dryness, effectively ensuring that any previously dissolved soluble impurities remain permanently mixed within the final resulting solid residue. Furthermore, delicate organic compounds like edible sugar can easily char or decompose upon continuous intense heating. During crystallization, perfectly pure solid separates out neatly into geometric patterns from a gradually cooling saturated solution, leaving all unwanted chemical impurities harmlessly suspended in the liquid.

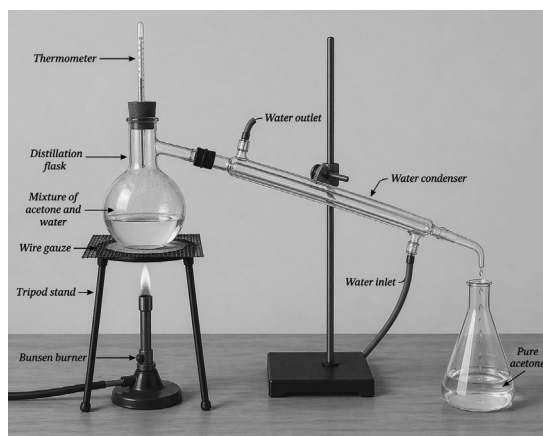
100. Compare biological colloids and standard suspensions explicitly with respect to their average microscopic particle size and their natural ability to physically settle down when left completely undisturbed over time.

Ans :

Colloids contain moderately sized active particles usually ranging anywhere between 1 nanometer and 1000 nanometers in their physical diameter. In stark contrast, standard chemical suspensions contain massively larger solid particles that effortlessly exceed 1000 nanometers in total diameter. When left entirely undisturbed on a flat surface, biological colloidal particles stubbornly remain uniformly dispersed throughout their liquid medium and absolutely never settle down, ensuring incredible stability. However, the significantly larger and heavier solid particles present within a suspension will always quickly settle down entirely due to standard gravitational forces.

increase in the overall thermal temperature. When the liquid water solvent is heavily heated, its billions of individual microscopic liquid molecules rapidly gain substantially more chaotic kinetic energy. They aggressively move around much faster and physically collide incredibly violently with the solid solute particles, shattering them apart violently. This massive increased thermal energy effectively creates more fluid molecular space, thereby seamlessly allowing a much larger quantity of absolute solute to be completely dissolved.

110. Study the given diagram of a chemical separation setup.



Identify the specific process shown. What fundamental chemical property allows the separation of liquid acetone and water in this complex setup?

Ans :

The specific process visibly demonstrated in this detailed diagram is simple distillation. This effective laboratory method is carefully utilized for separating a homogeneous mixture consisting of two miscible liquids that possess a highly significant mathematical difference in their respective boiling points. Because pure acetone features a dramatically lower boiling point of 56 degrees Celsius compared to water at 100 degrees Celsius, it rapidly vaporizes first upon heating. These resulting hot chemical vapours smoothly travel down the cold condenser tube, where they safely condense back into a pure liquid state.

111. What exactly is meant mathematically by the specific term 'mass by volume percentage (% m/v)'? Provide one highly practical everyday example of an exact situation where this specific chemical unit is heavily utilized.

Ans :

The mass by volume percentage mathematically serves as a highly standardized scientific method utilized to properly express the exact active concentration of a prepared chemical solution. It explicitly indicates precisely how many total solid grams of a completely pure chemical solute are fully dissolved evenly inside exactly 100 millilitres of the final resulting liquid solution. This highly specific measurement method is heavily preferred whenever quickly weighing the dry solid is physically easy but calculating final volume is easier. A perfect practical example is a standard medical intravenous saline drip in hospitals.

112. Explain the highly complex industrial process of fractional distillation. Why exactly is this exceptionally advanced method strictly utilized inside massive petroleum refineries instead of utilizing a basic simple distillation laboratory setup?

Ans :

Fractional distillation is a massive, highly complex industrial separation process heavily utilized worldwide to systematically separate an extremely complicated chemical mixture directly into its numerous distinct useful chemical components, firmly based entirely upon minor differences in boiling points. It is strictly primarily used inside massive crude oil petroleum refineries to successfully extract highly valuable distinct chemical fractions like liquid petrol, kerosene, and dense diesel directly from raw crude. It is absolutely mandated because these numerous hydrocarbon components naturally possess incredibly small temperature differences in boiling points, often significantly less than 25 degrees.

113. A student actively observes a standard solubility curve graph and confidently asserts that all known solid chemical substances visually show an exactly identical mathematical increase in total solubility as the water temperature rises. Justify your answer.

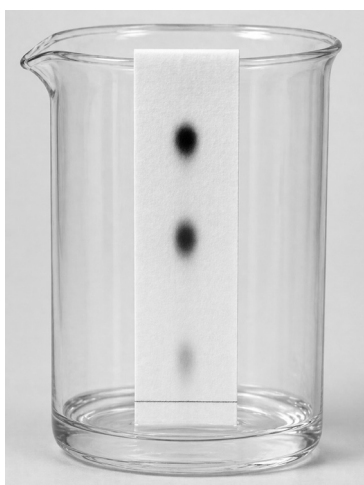
Ans :

I unequivocally disagree completely with the misinformed student's completely incorrect assertion because completely different unique chemical substances naturally exhibit entirely unique and completely different physical solubility behaviours whenever heated. While

body, truly vital organic organs exactly like our twin kidneys continuously act essentially as highly complex microscopic biological filters, incredibly efficiently and safely separating toxic chemical waste products entirely from our rapidly circulating blood. Similarly, massively large scale modern municipal wastewater sewage treatment plants heavily rely absolutely upon extremely massive separation techniques including thick sedimentation, intense coagulation, and rapid physical filtration completely.

122. Draw a simple laboratory setup perfectly showing the absolute endpoint of a successful paper chromatography experiment specifically for testing a green plant leaf extract. Why exactly is plain water or alcohol fundamentally able to carry pigments upwards?

Ans :



The selected liquid chemical solvent, whether simple plain liquid water or a harsh chemical alcohol, is completely miraculously successfully able to easily physically carry the various incredibly diverse dissolved coloured organic pigments heavily upward completely defying gravity entirely due to an extremely incredibly important natural physical phenomenon scientifically known strictly as capillary action. As the incredibly dense liquid slowly seamlessly soaks deeply and heavily rises actively through the completely microscopic internal porous fibres of the paper, it continuously vigorously drags the lighter dissolved dye molecules vertically upward entirely at totally varying different speeds.

LONG ANSWER QUESTIONS

123. (a) Define a saturated solution?
 (b) Why is temperature strictly specified when defining the solubility of a substance?
 (c) A student dissolves 15 g of common salt in 85 g of water. Calculate the mass by mass percentage of the solution?
 (d) What happens if a saturated solution of a solid in liquid is heated?

Ans :

- (a) A saturated solution is a solution in which no more solute can be dissolved in the solvent at a specific given temperature.
 (b) Temperature is strictly specified because the solubility of a solid solute in a liquid solvent generally increases as the temperature rises. Thus, a solution saturated at one temperature may become unsaturated when heated.
 (c) For the mathematical calculation:
 Mass of the solute (common salt) = 15 g
 Mass of the solvent (water) = 85 g
 Total mass of the solution

$$= \text{Mass of solute} + \text{Mass of solvent}$$

$$\text{Total mass} = 15 \text{ g} + 85 \text{ g} = 100 \text{ g}$$
 Mass by mass percentage

$$= (\text{Mass of solute} / \text{Mass of solution}) \times 100$$
 Mass by mass percentage

$$= (15/100) \times 100 = 15\%$$

 (d) Heating a saturated solution increases its kinetic energy, allowing it to dissolve even more solute.

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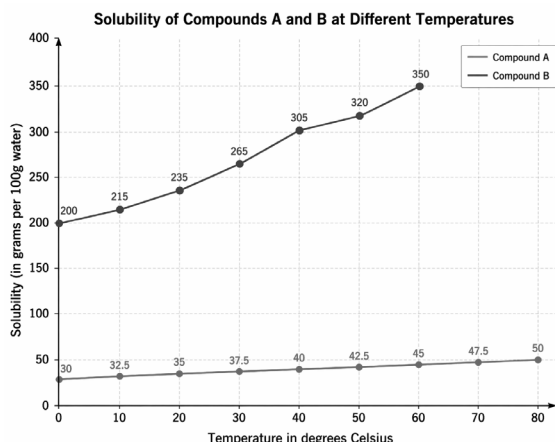
124. (a) How would you separate a mixture of mustard oil and water?
 (b) Explain the foundational principle behind the specific technique used?
 (c) If two completely immiscible liquids having the exact same density are mixed together, can they be separated using this standard apparatus? Justify your reasoning?

Ans :

- (a) To separate a mixture of mustard oil and water, one must use a separating funnel apparatus.

suspended within the indoor air. The dense indoor air effectively acts naturally as a massive heterogeneous colloidal mixture. These suspended microscopic airborne dust particles are physically large enough to physically intercept and violently scatter the straight incoming light waves. This is the Tyndall effect.

118. Study the detailed visual description of a scientific chemical solubility curve.



Which precise chemical compound's physical solubility is wildly more heavily affected by heat? What exactly happens if Compound B cools down?

Ans :

Based strictly upon analyzing the visual mathematical data expertly provided by the drawn graph, chemical Compound B's absolute physical solubility is significantly and wildly more heavily affected completely by sudden rising thermal temperature changes, as explicitly indicated perfectly by its extremely violently steep upward sweeping curve. Compound A obviously visually shows only an incredibly minor, exceptionally gradual flat increase. If a boiling hot, massively concentrated saturated solution exactly of Compound B violently resting strictly at 60 degrees is slowly actively cooled, vast excess solid material will incredibly rapidly heavily precipitate out.

119. What essentially happens on a microscopic level when boiling hot liquid elemental metals are completely mixed and successfully allowed to cool down? Why exactly can't standard physical separation methods safely separate the components of this resulting solid?

Ans :

When completely different boiling hot liquid elemental metals are deliberately violently mixed together directly at extremely high thermal temperatures and subsequently slowly allowed to cool totally, they firmly solidify permanently into a completely new, entirely homogeneous dense solid material scientifically known as a metallic alloy. Although a solid alloy fundamentally remains classified strictly as a physical mixture, standard basic physical methods absolutely cannot separate its atomic components because the distinct constituent metal atoms unfortunately become permanently, uniformly, and incredibly tightly interlocked totally within a highly rigid, continuous solid metallic crystal lattice structure.

120. What precise physical failure would immediately happen if a confused student foolishly attempted to perfectly separate a highly concentrated liquid mixture of pure acetone and pure alcohol solely utilizing a standard laboratory separating funnel?

Ans :

If the thoroughly confused student foolishly attempted to desperately use a standard glass separating funnel to perfectly separate a prepared mixture of pure acetone and liquid alcohol, the flawed method would absolutely fail instantly, granting zero physical separation. A standard separating funnel intrinsically relies entirely strictly upon the basic fundamental physical principle of massively distinct liquid density differences existing strictly between two purely immiscible liquids that completely refuse to organically mix. However, both liquid acetone and liquid alcohol are extremely highly miscible, freely dissolving permanently into a totally inseparable single phase.

121. Explain clearly how the extremely important fundamental physical principle of biological mixture separation is naturally utilized continuously by the internal human body and heavily by large scale modern municipal wastewater sewage treatment plants.

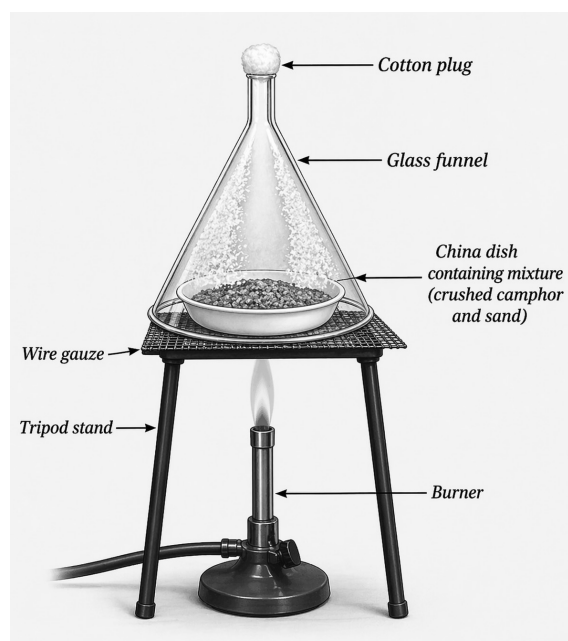
Ans :

The highly essential physical principle of complex mixture separation is absolutely vital for continuously sustaining healthy internal organic life and heavily maintaining our external environment. Deep inside the internal human

specific active chemical coagulant directly into a vast heterogeneous mixture to rapidly force tiny microscopic suspended particles to clump together. When fine powdered alum is aggressively mixed into cloudy muddy water, it immediately acts as an incredibly effective chemical coagulant. The entirely dissolved alum structurally causes the extremely fine, lightweight mud particles to aggregate massively into significantly larger, surprisingly heavy solid clumps. These newly formed massive clumps then sink effortlessly to the bottom due to natural gravity.

106. Draw a cleanly labelled diagram of the precise setup used to safely separate a physical mixture of crushed camphor and raw sand. What exactly happens to the camphor molecules during this heating process?

Ans :



When the dry mixture situated inside the white china dish is continuously heated gently by the burner, the completely solid camphor molecules undergo rapid sublimation. They aggressively absorb immense thermal energy and physically transform directly into a hot chemical gas without ever melting into a messy liquid state. These highly energetic hot vapours quickly rise upwards and violently hit the much cooler upper inner walls of the glass funnel. Here, they rapidly condense directly back into pure solid camphor crystals through deposition, leaving the sand totally untouched below.

107. Define the specialized scientific terms 'dispersed phase' and 'dispersion medium' specifically within the context of a colloidal solution. Accurately identify both of these exact components within the common case of drinking milk.

Ans :

Within a complex colloidal system, the dispersed phase explicitly refers to the active solute-like component that remains permanently distributed or physically suspended entirely in the form of extremely fine microscopic particles. Alternatively, the dispersion medium is defined as the surrounding continuous bulky substance or massive solvent field in which these tiny microscopic particles actively remain suspended indefinitely. In the specific chemical case of standard drinking milk, which is a classic emulsion, liquid milk fat essentially acts as the dispersed phase, while pure liquid water serves as the vast dispersion medium.

108. What specific chemical and biological consequences would immediately occur if a careless farmer accidentally mixed precisely double the officially recommended amount of chemical pesticide solute into his fixed standard volume of agricultural water?

Ans :

If the careless farmer accidentally heavily doubles the recommended powdered amount of agricultural pesticide inside the exact same fixed volume of mixing water, the overall final concentration of the resulting chemical solution will become dangerously excessive. The perfectly precise mass proportion of active solute to solvent is totally essential for maintaining safe agricultural plant application. Actively spraying this incredibly highly concentrated, toxic chemical solution would rapidly result in massive cellular damage to the delicate crop plants, instantly causing them to wither. The harsh chemicals would aggressively poison the local soil completely.

109. Explain in detailed molecular terms exactly why a solid crystalline solute generally dissolves significantly faster and in far greater absolute quantities inside boiling hot water when compared directly to freezing cold water.

Ans :

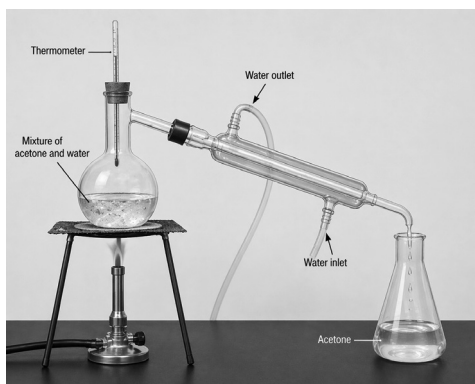
The physical solubility of most standard solid solutes directly within liquid solvents generally increases tremendously alongside a significant

- (b) The fundamental principle behind this technique is that immiscible liquids do not mix and will naturally separate into distinct layers depending upon their respective densities. Because water is denser than mustard oil, water settles at the bottom of the funnel, while the lighter mustard oil forms the upper layer. You carefully open the stopcock to collect the water layer first, closing it just before the oil reaches the bottom.
- (c) If two immiscible liquids possess the exact same density, they cannot be successfully separated using a basic separating funnel. Since gravity pulls equally on both liquids relative to their volume, neither liquid will inherently sink or float. Without a density difference, clear top and bottom layers will never form, rendering this gravitational separation useless.

125. (a) Draw a labelled diagram of the apparatus used to separate a mixture of acetone and water?
- (b) Explain the scientific principle behind this separation technique?
- (c) Why is this method highly suitable for separating acetone and water but not for separating crude petroleum components?

Ans :

- (a)



- (b) The basic principle of simple distillation relies on a significant difference in the boiling points of two miscible liquids. The mixture is heated until the liquid with the lower boiling point vaporizes. These vapours travel into a condenser where they are cooled back into a liquid state and collected separately, leaving the higher boiling point liquid behind in the distillation flask.

- (c) This specific separation method is highly suitable for an acetone and water mixture because their boiling points differ by more than twenty-five degrees Celsius. Acetone boils at fifty-six degrees Celsius, while water boils at one hundred degrees Celsius. However, petroleum components have very closely spaced boiling points, usually differing by less than twenty-five degrees Celsius. Therefore, simple distillation fails to separate them purely, and complex fractional distillation must be used instead to isolate the petroleum fractions.

126. (a) What is the Tyndall effect?
- (b) Why does a true homogeneous solution absolutely fail to show this visual effect?
- (c) Differentiate between a colloid and a suspension specifically based on particle size and settling behaviour?
- (d) Finally, identify the dispersed phase and dispersion medium in atmospheric clouds?

Ans :

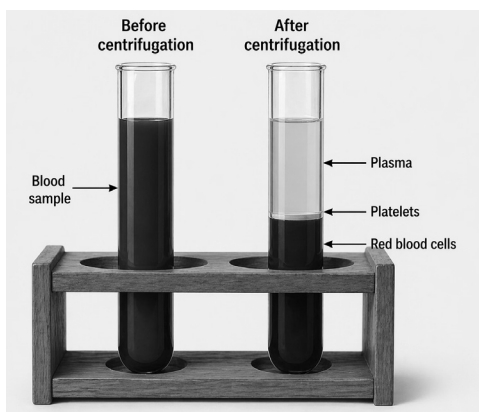
- (a) The Tyndall effect is the phenomenon where a beam of light becomes visible as it passes through a medium because the particles in that medium scatter the light.
- (b) A true solution does not exhibit this effect because its dissolved solute particles are incredibly small, measuring less than one nanometre in diameter, which is insufficient to scatter visible light waves.
- (c) A colloid differs from a suspension primarily in particle size and stability. Colloidal particles range between one and one thousand nanometres and remain uniformly distributed without settling down over time. In contrast, suspension particles are larger than one thousand nanometres and are unstable, settling down at the bottom due to gravity when left undisturbed.
- (d) In the specific case of clouds, the dispersed phase consists of liquid water droplets or solid ice crystals, while the dispersion medium is the surrounding gaseous air.

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it fundamentally remains broadly accurate that the general solubility of most common solid compounds dissolved in liquid water typically increases with rising thermal temperature, the absolute mathematical rate of this increase varies drastically. A plotted solubility curve clearly reveals that some unique compounds experience a massive dramatic vertical rise, whereas other chemicals might show almost zero mathematical change whatsoever.

114. Draw a clear diagram explicitly showing a glass test tube of medical blood immediately before and quickly after intense rapid centrifugation. Briefly explain the exact physical visual changes properly observed inside the glass tube.

Ans :



Before the intense mechanical spinning, the freshly donated medical blood completely appears flawlessly as a single entirely uniform dark red opaque colloidal mixture. However, immediately after undergoing extremely rapid mechanical centrifugation, the genuinely immense physical outward centrifugal force violently forces the heaviest dense solid microscopic components to violently settle completely at the extreme bottom. Consequently, the incredibly dense red blood cells clearly perfectly separate downward, while a tiny microscopic white layer smoothly forms. The exceptionally lightest liquid component, plasma, effectively remains safely floating totally cleanly above everything else.

115. What exactly is meant strictly by the term 'volume by volume percentage (% v/v)' in chemistry? Exactly how is this specific percentage mathematically calculated properly for a mixed liquid chemical mixture?

Ans :

The volume by volume percentage fundamentally serves as a highly useful and robust mathematical method utilized to properly express the precise final concentration of a chemical solution completely created exclusively by permanently mixing two completely miscible liquid substances. It explicitly dictates exactly how many exact millilitres of pure liquid solute are safely present completely within every 100 millilitres of the totally combined liquid solution. To calculate this mathematically, simply divide the precise pure liquid solute volume directly by the total completely combined mixed solution volume, then strictly multiply by one hundred.

116. Compare biological oil-in-water colloidal emulsions directly against water-in-oil colloidal emulsions specifically with respect to their unique dispersed phase and continuous medium. Accurately provide one highly common daily life physical example of each emulsion type.

Ans :

Both entirely unique types represent specific subcategories of complex colloidal emulsions involving completely entirely immiscible liquids. Inside a biological oil-in-water emulsion, tiny microscopic droplets of oily fat successfully act strictly as the internal dispersed phase, completely suspended continuously throughout vast liquid water acting as the continuous dispersion medium. A perfect daily life example is liquid drinking milk. Conversely, a standard water-in-oil emulsion fundamentally features microscopic pure water droplets uniformly dispersed permanently throughout a massively larger, continuous thick oily medium. A perfectly standard everyday physical example is standard solid dairy butter.

117. Explain scientifically exactly why a perfectly straight fine beam of intense white light entering a pitch-black dark room rapidly through a tiny hole suddenly becomes physically visible to the human eye.

Ans :

Whenever a perfectly straight, highly intense beam of pure light rapidly enters an almost completely dark enclosed room, its exact linear physical path immediately becomes vibrantly visible entirely due to the huge presence of millions of randomly scattered microscopic dust particles and tiny floating smoke droplets permanently

sand and salt mixture and stir thoroughly. The common salt will dissolve completely, while the sand remains insoluble. Filter the mixture to collect the sand as the solid residue. Finally, gently evaporate the clear filtrate to remove the water, leaving pure solid common salt behind.

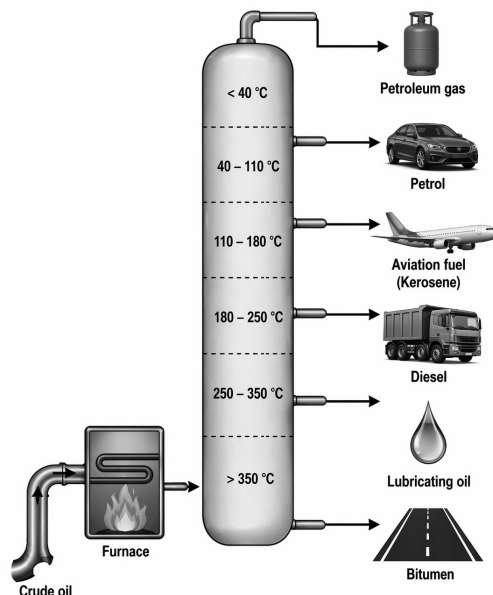
- 130.** (a) How exactly does the process of centrifugation help in separating microscopic particles from a liquid mixture?
- (b) Mention one critical application of this technique in the modern medical field?
- (c) If a sample of muddy water remains distinctly cloudy even after standard filtration, how can you rapidly clear it using coagulation?

Ans :

- (a) Centrifugation separates complex mixtures by spinning them rapidly inside an electric machine. This rapid rotation generates a strong outward centrifugal force. The heavier, denser solid particles are forced forcefully outward and settle rapidly at the bottom of the test tube, while the much lighter liquid components remain suspended at the top.
- (b) A primary application in the medical field is separating whole blood into distinct layers of red blood cells, platelets, and clear plasma for diagnostic testing.
- (c) When muddy water remains cloudy despite traditional filtration, the tiny suspended particles can be separated utilising chemical coagulation. By adding powdered alum to the cloudy liquid, the alum acts directly as a coagulant. It causes the microscopic, suspended clay particles to clump together into significantly larger, heavier masses. These heavy clumps then settle downward efficiently by gravity, allowing clear water decantation.
- 131.** (a) Draw a labelled flowchart or schematic diagram illustrating the primary products obtained from the fractional distillation of crude oil?
- (b) How does fractional distillation fundamentally differ from simple distillation in terms of its application parameters?
- (c) Why must raw crude petroleum be separated using this specific, complex technique?

Ans :

(a)



- (b) Fractional distillation is specifically utilised to separate liquid mixtures where the boiling points of the miscible components differ by a very narrow margin, specifically less than twenty-five degrees Celsius. Simple distillation is entirely ineffective here and is only used when the boiling point difference is substantial.
- (c) Crude petroleum is an incredibly complex mixture of numerous valuable hydrocarbon liquids. Because these various components, such as petrol, diesel, and kerosene, have densely packed boiling points, simple evaporation and condensation would produce heavily mixed, impure liquids. To resolve this, crude oil is processed in a massive fractional distillation column. The oil is vaporized entirely, and as the vapours rise up the tall column, it slowly cools. Different fractions condense at highly specific height zones based directly on their unique boiling points, allowing the simultaneous collection of multiple pure industrial fuels.

132. (a) A concentrated liquid pesticide spray is heavily diluted by mixing 25 mL of the active pesticide with pure water to make a total volume of 500 mL. Calculate its final volume by volume percentage?
- (b) Explain exactly what an emulsion is, providing an everyday example, and explain how emulsifying agents function?

Ans :

- (a) To calculate the concentration properly, use the standard volume by volume percentage formula. The volume of the solute, which is the concentrated pesticide, equals twenty-five millilitres. The total combined volume of the final aqueous solution is given as five hundred millilitres. The mass by volume percentage equals the solute volume divided by the total solution volume, multiplied by one hundred. Therefore, dividing twenty-five by five hundred yields zero point zero five. Multiplying this by one hundred results in a final concentration of exactly five percent.
- (b) An emulsion is a distinct category of colloidal mixture where both the dispersed phase and the surrounding dispersion medium are mutually immiscible liquids. Everyday milk is a perfect example. Emulsifying agents, such as natural milk proteins, effectively stabilize these mixtures by preventing the suspended liquid droplets from aggressively coalescing and separating into distinct layers.

CASE BASED QUESTIONS

133. During a school play, the drama club used a smoke machine to create a thick, mysterious fog on stage. As the stage lights turned on, the audience could clearly see the bright, solid-looking beams of light piercing through the fog. Meanwhile, one of the actors was holding a glass of a clear, purple-coloured sports drink as a prop. When a stray spotlight hit the glass, the light passed straight through it, but no beam was visible inside the purple liquid itself.

QUESTIONS:

- (a) Classify the fog on the stage and the sports drink in the glass as homogeneous or heterogeneous mixtures.
- (b) What is the scientific name for the phenomenon that makes the light beams visible in the stage fog?

- (c) Why was the path of the light beam visible in the fog but not in the clear sports drink?
- (d) Based on particle size, what specific type of mixture is the fog likely to be?

Ans :

- (a) The fog is a heterogeneous mixture, while the clear sports drink is a homogeneous mixture (a solution).
- (b) The phenomenon is known as the Tyndall effect, which is the scattering of light by particles.
- (c) The particles in the fog are large enough to scatter the light, making the beam's path visible. The sports drink is a true solution with particles less than 1 nm in diameter, which are too small to scatter light.
- (d) The fog is a colloid (or an aerosol, which is a specific type of colloid with a gas as the dispersion medium).

134. During a local marathon in the summer, a medical volunteer named Priya is tasked with preparing rehydration fluids for the runners. She needs to prepare a specific glucose drip for a runner who has collapsed from exhaustion. The doctor instructs her to quickly prepare 300 mL of a 5% m/v (mass by volume percentage) glucose solution. Priya has a large container of pure glucose powder and several bottles of sterile distilled water at her medical station.

QUESTIONS:

- (a) Identify the solute and the solvent in the mixture Priya is preparing.
- (b) Calculate the exact mass of glucose powder Priya needs to measure out to prepare 300 mL of the required 5% m/v solution.
- (c) Why is it important for Priya to mix the exact right proportion of glucose and water, rather than just guessing the amounts?

Ans :

- (a) The solute is the glucose powder, and the solvent is the sterile distilled water.
- (b) Mass by volume percentage

$$= (\text{Mass of solute} / \text{Volume of solution}) \times 100$$

$$\text{So, } 5 = (\text{Mass of glucose} / 300) \times 100$$

$$\text{Mass of glucose}$$

$$= (5 \times 300) / 100$$

$$= 15 \text{ grams.}$$

Priya needs 15 grams of glucose.

- (c) The right proportion is essential because changing the amounts alters the concentration. Just like ORS or medicines, a specific concentration is required for the fluid to be safe and effective for the body; an incorrect concentration might harm the patient or fail to rehydrate them properly.

135. A local sweet-shop owner (halwai) is preparing thick sugar syrup, locally known as chashni, for making traditional sweets. He pours a massive amount of sugar into a vat of water and begins to heat it over a stove. Even though the water initially couldn't dissolve all the sugar, as the temperature rises, the sugar disappears completely into the liquid. After dipping the sweets, he turns off the stove and lets the leftover syrup sit overnight. By the next morning, he notices that solid sugar crystals have formed on the bottom and sides of the vat.

QUESTIONS:

- What term describes the hot sugar syrup when it cannot dissolve any more sugar at that specific high temperature?
- Why was the halwai able to dissolve extra sugar in the water by heating it?
- Explain why the solid sugar crystals reappeared in the vat the next morning.

Ans :

- The syrup is called a saturated solution at that specific temperature.
- He was able to dissolve more sugar because the solubility of a solid solute in a liquid solvent generally increases with an increase in temperature.
- As the syrup cooled overnight, the temperature dropped, causing the solubility of the sugar to decrease. The extra sugar that could no longer stay dissolved separated out from the solution as solid crystals.

136. While working in his garage, a mechanic accidentally knocks a small bottle of yellow engine oil into a bucket of water. Knowing that engine oil is expensive, he wants to recover as much of the pure oil as possible. He notices that the oil and water do not mix, and after a few minutes of standing undisturbed, a distinct yellow layer forms on top of the clear water. He remembers a lesson from his school days about a specific piece of laboratory glass equipment that operates on this exact principle.

QUESTIONS:

- What type of mixture is formed when the engine oil spills into the water?
- Name the laboratory apparatus that the mechanic could use to efficiently separate these two liquids if he were in a science lab.
- Why does the engine oil form the upper layer while the water forms the lower layer?
- Briefly describe the steps he would take using the laboratory apparatus to collect the water and oil separately.

Ans :

- It is a heterogeneous mixture of two immiscible liquids.
- A separating funnel can be used to separate them.
- Oil forms the upper layer because it has a lower density than water, causing it to float on top.
- He would pour the mixture into the separating funnel and let it stand so the layers separate. Then, he would open the stopcock to drain the lower water layer into a flask, close it when the water is drained, and then collect the remaining oil in a separate container.

137. Before the onset of winter, Rohan's grandmother brings out heavy woolen blankets from an old wooden trunk. Rohan notices a strong smell and sees that his grandmother is placing small, white naphthalene balls between the folds of the blankets before putting them away again in the spring. Six months later, when the blankets are unpacked again, Rohan looks for the white balls to throw them away, but he cannot find them. There are no liquid stains on the blankets either. The balls seem to have vanished entirely.

QUESTIONS:

- What specific physical change caused the naphthalene balls to vanish without leaving wet stains?
- Define the process identified in CBQ1.
- If Rohan mixed crushed naphthalene with normal sand by mistake, how could he separate the sand from the naphthalene?
- Name one other common substance, often used in ice cream storage, that undergoes this same process.
- Is the melting of an ice cube the same type of physical change as the vanishing of the naphthalene balls? Justify your answer.

Ans :

No, the forces are not balanced because the arms are moving and accelerating in a specific direction. The player who is applying their force in the direction of the tilt (out of the page towards you) has exerted the larger force.

3. An object is moving with a constant velocity. Is there a net force acting upon it?

Ans :

No, there is no net force acting upon it. According to Newton's first law of motion, an object maintains a constant velocity only when the net external force acting on it is zero.

4. Suppose, no net force is acting on an object. Which of the following situations are possible?
- Object remains at rest if at rest.
 - Object keeps moving with a constant velocity if already moving.
 - Object is moving with a constant acceleration.

Ans :

Only situations (i) and (ii) are possible when no net force is acting on an object. Situation (iii) is not possible because having a constant acceleration requires a continuous, non-zero net force.

5. In the real world, it is difficult to find a situation where no forces are acting on an object. But by applying additional forces, a condition can be achieved where the net force on the object is zero. Explain with the help of an example.

Ans :

In everyday life, forces like friction and gravity are always present and acting on objects. However, we can create a zero net force situation by applying an external force that exactly balances these opposing forces. For example, if you push a heavy box across the floor at a constant speed, the forward pushing force you apply is exactly equal to the backward force of friction. Because these forces cancel each other out, the net force is zero and the box does not accelerate.

6. A toy car of mass 100 g is moving with a constant velocity of 0.5 ms^{-1} . What is the net force acting on the toy car?

Ans :

The net force acting on the toy car is zero. Because the car is moving with a constant velocity, its

acceleration is zero, which implies that all forces acting on it are perfectly balanced.

7. Two children of different masses are sitting on identical swings. To impart identical initial acceleration, for which child would you require to apply a larger force? Explain why.

Ans :

You would require a larger force to accelerate the child with the greater mass. According to Newton's second law of motion, force is equal to mass multiplied by acceleration. Therefore, to achieve the exact same acceleration, a heavier object inherently requires a proportionally larger applied net force.

8. How are glass items packed for transportation using a bubble wrap or hay protected from damage?

Ans :

Materials like bubble wrap or hay are highly compressible and act as soft cushions for fragile items. During a sudden stop or collision, these materials increase the time duration over which the glass item comes to rest. By increasing the time of the impact, the rate of change of momentum is decreased, which results in a much smaller force being exerted on the glass, thereby preventing it from breaking.

9. Why does a fire person sometimes struggle when holding the pipe issuing water?

Ans :

A fire person struggles because of the equal and opposite reaction principle described by Newton's third law of motion. The hose pipe exerts a large forward force to push a massive amount of water out at high speeds. Simultaneously, the rushing water exerts an equally large backward reaction force on the pipe, causing a strong recoil that the fireperson must constantly fight to hold steady.

10. Suppose a spacecraft is moving in a region of space where the gravitational force acting upon it is negligible. Suggest how can it change its velocity.

Ans :

To change its velocity in the absence of external forces like gravity, the spacecraft must use its own thrusters or engines. By expelling exhaust gases backward at a high speed, the spacecraft

- 140.** Dr. Ahmed runs a mobile clinic in a remote village with frequent power cuts. He needs to test blood samples for anemia by separating the heavier red blood cells from the lighter plasma. Since he cannot use an electric machine, he uses a 'paperfuge'—a simple disk made of cardboard and string that he spins rapidly by pulling the strings. In another part of the village, a farmer is using a piece of alum (fitkari) to clean buckets of highly muddy river water, waiting for the fine dirt to clump and settle.

QUESTIONS:

- What is the separation technique Dr. Ahmed is imitating with his hand-powered paperfuge?
- State the fundamental principle behind Dr. Ahmed's separation technique.
- According to the textbook, how is a blood mixture classified?
- What is the scientific term for the process the farmer is using to clear the muddy water?
- How exactly does the alum (fitkari) help in cleaning the farmer's muddy water?

Ans :

- Dr. Ahmed is using centrifugation.
- The principle is that when a mixture is spun rapidly, centrifugal force pushes the heavier particles to the bottom (or outward), while the lighter components remain at the top (or center).
- Blood is classified as a colloid.
- The process is called coagulation.
- Alum acts as a coagulant. It causes the fine suspended mud particles, which would otherwise take a long time to settle, to clump together into larger, heavier masses that easily settle down at the bottom by gravity.

- 141.** A local dairy cooperative produces fresh paneer (cottage cheese) every morning. To make the paneer, workers heat large vats of fresh milk and add natural lemon juice. Almost immediately, the uniform liquid begins to separate into solid white curds and a watery, greenish-yellow liquid called whey. The heavy curds are then strained through a clean muslin cloth, pressed to remove excess water, and sold in blocks.

QUESTIONS:

- What scientific process occurs when lemon juice is added to the milk to form the curds?
- What role does the lemon juice play in this process?

- What separation technique is used when the workers pass the curd and whey mixture through the muslin cloth?

Ans :

- The process is called coagulation (specifically, the coagulation of milk proteins).
- The lemon juice (which contains acid) acts as a coagulant, causing the proteins in the milk to clump together into larger solid masses (curds).
- The separation technique used with the muslin cloth is filtration.

- 142.** A class of Grade 9 students visits a factory that processes salt harvested from the sea. The guide explains that the initial salt obtained by evaporating seawater in open pans contains a lot of unwanted dirt, grit, and other chemical impurities. To purify it, the factory dissolves this impure salt in hot water to make a highly concentrated solution, filters it, and then allows the hot solution to cool slowly in large stainless-steel tanks. Eventually, brilliant, pure white geometric shapes of salt begin to form at the bottom of the tanks.

QUESTIONS:

- What is the scientific name for the pure, geometric shapes of solid salt forming at the bottom of the tanks?
- Identify the technique used by the factory to obtain the pure solid salt from the hot, concentrated solution.
- Why is it necessary to filter the hot solution before allowing it to cool?
- Why is the factory's cooling technique considered a better purification method than simply boiling the saltwater mixture until all the water evaporates (dryness)?

Ans :

- They are called crystals.
- The technique is crystallization.
- Filtration of the hot solution is necessary to remove the insoluble impurities (like dirt and grit) before the pure crystals start to form.
- Crystallization is better than simple evaporation to dryness because evaporation might leave soluble impurities mixed with the solid, whereas crystallization specifically separates the pure substance as crystals, leaving the soluble impurities behind in the remaining liquid.

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CHAPTER 6

How Forces Affect Motion

SUMMARY

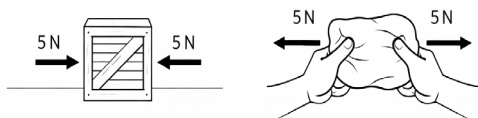
1. FORCE

It is a push or pull. A force acting on a body changes or tries to change its state of rest or motion or changes the direction of motion. A force may start motion of an object, may change the speed of a moving object, may stop a moving object, may change the direction of an object or may deform an object.

2. TYPE OF FORCE

The force is classified into two parts which is as follows :

1. **Balanced forces** : When two or more forces acting simultaneously on an object do not change its state of rest or of uniform linear motion, the forces are said to be balanced forces. The net resultant of all the balanced forces is zero. Balanced forces do not change the state of rest or of uniform linear motion of an object, but they can deform the object.



2. **Unbalanced forces** : When two or more forces acting simultaneously on an object change its state of rest or of uniform linear motion, the forces are said to be unbalanced forces. The net resultant of all the unbalanced forces is non-zero.

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3. GALILEO'S CONCEPT OF MOTION

Galileo, based on his experimental studies, concluded that objects move with a constant velocity if no external unbalanced force acts on them. On the other hand, net unbalanced external force not required to maintain uniform motion of an object along a straight line.

Based on his experimental studies, Newton gave three fundamental laws which are called Newton's laws of motion.

4. NEWTON'S FIRST LAW OF MOTION

It states that an object remains in its state of rest or of uniform linear motion unless compelled by some external unbalanced force.

Newton's first law of motion defines force. Thus, force is an external effort, i.e., a push or a pull, which changes or tends to change the state of rest or of uniform linear motion of an object on which it acts.

Newton's first law of motion is also called the law of inertia.

5. INERTIA

It is inherent property of an object by virtue of which it resists any change in its state of rest or of uniform linear motion. Mass of an object is a measure of its inertia. Higher the mass of an object, larger is its inertia.

5.1 Types of Inertia

Inertia is of three types : (i) inertia of rest, (ii) inertia of motion and (iii) inertia of direction.

- (i) **Inertia of rest** : It is the inherent property of an object at rest by virtue of which it opposes any change in its state of rest by itself in the absence of some external unbalanced force.

- (ii) **Inertia of motion** : It is the tendency of a moving object to oppose any change in its state of uniform motion along a straight line by itself.
- (iii) **Inertia of direction** : It is the tendency of an object to oppose any change in its direction of motion.

6. MOMENTUM

It is the product of mass and velocity of a moving object.

Thus,

$$\text{Momentum (p)} = \text{Mass (m)} \times \text{velocity (v)}$$

Momentum is a vector quantity and its SI unit is kg m s^{-1} .

7. NEWTON'S SECOND LAW OF MOTION

It states that the rate of change of momentum of an object is directly proportional to the applied unbalanced force and the change in momentum in the direction of applied force.

According to second law of motion,

$$\text{Force (F)} = \text{Mass (m)} \times \text{acceleration (a)}$$

Thus, the force acting on an object is equal to the product of the mass of the object and acceleration produced in it by that force. It is a vector quantity and its direction is same as that of the acceleration produced by it.

1. Newton's second law of motion gives the magnitude of force as well as the unit of force.
2. The SI unit of force is newton (N). Force is said to be 1 newton if it produces an acceleration of
3. 1 m s^{-2} when acting on an object of mass 1 kg.

$$\text{Thus, } 1 \text{ N} = 1 \text{ kg m s}^{-2}$$

8. NEWTON'S THIRD LAW OF MOTION

It states that 'to every action, there is an equal and opposite reaction'.

As per Newton's third law of motion, whenever one object exerts a force on another object, the second object instantaneously exerts a force back on the first object. These two forces are always equal in magnitude but opposite in direction and act simultaneously. But action-reaction forces never cancel one another as they act on two different objects.

9. LAW OF CONSERVATION OF MOMENTUM

As per law of conservation of momentum, for an isolated system, the total momentum of the system always remains conserved. The law of conservation of momentum is easily obtain, from Newton's laws of motion. The law of conservation of momentum never fails because it is a universal law.

PAUSE AND PONDER

1. A weight lifter lifts a barbell as shown in the figure . List two forces that are acting on the barbell. Are these forces balanced if the weight lifter keeps the barbell steady?



Ans :

The two primary forces acting on the barbell are the downward gravitational force exerted by the Earth and the upward force applied by the weightlifter's hands. Yes, if the weightlifter keeps the barbell completely steady, these two opposing forces are equal in magnitude and are balanced.

2. Two players R and S are participating in an arm-wrestling match as shown in the figure . At the instant, when the arms tilt to the front direction (out of the page towards you), are the forces exerted by the players balanced? If not, which player exerted the larger force?



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Ans :

- The naphthalene balls underwent sublimation.
- Sublimation is the process where a solid changes directly into the vapour state on heating (or at room temperature for some volatile substances) without passing through the liquid state.
- He could put the mixture in a china dish with an inverted funnel plugged with cotton over it, and heat it gently. The naphthalene would sublime and form solid deposits on the inner walls of the funnel, leaving the sand behind.
- Solid carbon dioxide, also known as dry ice, undergoes sublimation.
- No, they are not the same. Ice melting into water is fusion (changing from solid to liquid), whereas sublimation skips the liquid phase entirely, turning directly from a solid into a gas.

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- 138.** A forensics student is investigating a case of a forged signature on a cheque. The suspect claims the signature was written using a standard black sketch pen found in the office. The student decides to test the ink. She places a tiny spot of ink from the cheque onto a thin strip of specialized filter paper. She carefully suspends the paper in a beaker containing a small amount of water, ensuring the ink spot sits just above the water level. After twenty minutes, she observes a beautiful band of blue, yellow, and red streaks climbing up the paper.

QUESTIONS:

- Identify the scientific technique being used by the forensics student to analyze the ink.
- What can the student infer about the black ink based on the coloured streaks on the paper?
- Explain the basic principle that allows the different colours to separate on the paper.
- Why was it crucial for the student to keep the ink spot slightly above the water level at the beginning of the experiment?

Ans :

- The technique is paper chromatography.
- The student can infer that the black ink is not a single pure substance, but a homogeneous mixture of multiple coloured components (dyes).

- The separation is based on differences in the interactions of the components with the solvent and the paper. As the solvent (water) rises, it carries the dyes with it at different speeds, separating them.
- If the ink spot was submerged in the water, the ink would simply dissolve into the bulk of the water at the bottom of the beaker instead of travelling up the paper strip.

- 139.** During a practical exam, a student accidentally pours acetone into a flask that contains pure distilled water. Acetone is highly miscible in water, resulting in a perfectly clear mixture. The teacher informs the student that the boiling point of water is 100 °C, while the boiling point of acetone is much lower, at 56 °C. She challenges the student to set up an apparatus to recover both liquids in their pure forms without losing either to the atmosphere.

QUESTIONS:

- Name the process the student should use to separate this mixture of miscible liquids.
- Why is this specific separation process effective for the acetone and water mixture?
- As the mixture is heated, which liquid will turn into vapour first, and why?
- What is the role of the water condenser in this apparatus?
- If the student had mixed two liquids with boiling points of 75 °C and 78 °C, could this exact same simple setup be used effectively? Explain.

Ans :

- The student should use the distillation process.
- Distillation is effective because acetone and water are miscible liquids that boil without decomposition and have a sufficient difference in their boiling points (greater than 25 °C).
- Acetone will vaporize first because it has a lower boiling point (56 °C) compared to water (100 °C).
- The condenser cools the hot vapours of the vaporized liquid (acetone) by circulating cold water around it, turning the vapour back into a liquid so it can be collected in a separate flask.
- No, simple distillation would not be effective because the difference in boiling points is less than 25 °C. For such closely boiling liquids, a fractional distillation setup would be required.

exerts a strong force on the gases. According to Newton's third law, the gases exert an equal and opposite forward reaction force on the spacecraft, providing the net force needed to accelerate and alter its velocity.

NCERT EXERCISE

- Using a horizontal force F , a table is moved across the floor at a constant velocity. How much is the frictional force exerted by the floor on the table?

Ans :

Since the table is moving at a constant velocity, the net force acting on it is zero. Therefore, the frictional force exerted by the floor on the table must be equal in magnitude and opposite in direction to the applied horizontal force F .

- For a ball moving on a smooth frictionless surface, choose the appropriate option that will make the following statements physically correct.
 - If no net force is applied on the ball, the velocity of the ball will remain the same/increase/decrease.
 - If a net force is applied on the ball in the direction of its motion, the magnitude of the velocity of the ball will remain the same/increase/decrease.
 - If a net force is applied on the ball in a direction opposite to the direction of its motion, the magnitude of the velocity of the ball will remain the same/increase/decrease.

Ans :

- remain the same

According to Newton's first law of motion, an object in motion will continue to move with a constant velocity unless acted upon by a net external force.

- increase

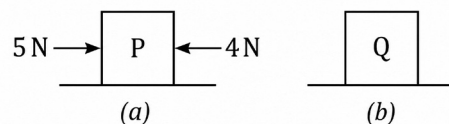
A net force applied in the direction of motion provides an acceleration in the same direction, causing the velocity to increase.

- decrease

A net force applied opposite to the motion causes deceleration, which reduces the magnitude of the ball's velocity.

- Two blocks P and Q on a smooth horizontal surface are shown in Figure.a and Figure. b. Two forces of magnitudes 4 N and 5 N are acting in

opposite directions on block P, while block Q is moving with a constant velocity.



Which of the following statement is correct?

- P experiences a net force and Q does not experience a net force.
- P does not experience a net force and Q experiences a net force.
- Both P and Q experience a net force.
- Neither P nor Q experiences a net force.

Ans :

Option (i) is correct.

Block P experiences unbalanced forces (5 N right and 4 N left), resulting in a net force of 1 N. Block Q is moving with constant velocity, which implies its acceleration is zero, so it experiences zero net force according to Newton's first law.

While practising for the snake boat race (Vallum kalli in Kerala), 100 oarsmen are rowing a boat together. Out of these, 95 row backwards to propel the boat forward. But by mistake, 5 oarsmen row in the opposite direction. If each oarsman applies a horizontal force of 200 N, what is the net force on the snake boat? (Ignore drag forces, air friction, etc.)

Ans :

The 95 oarsmen rowing backwards propel the boat forward with a total force = $95 \times 200 \text{ N}$
 $= 19,000 \text{ N}$.

The 5 mistaken oarsmen row forwards, pushing the boat backwards with a total force

$$= 5 \times 200 \text{ N} = 1,000 \text{ N}.$$

The net force acting on the snake boat

$$= 19,000 \text{ N} - 1,000 \text{ N}$$

$$= 18,000 \text{ N in the forward direction.}$$

- When a net force acts on an object, we observe that the object accelerates:
 - opposite to the direction of force, with acceleration proportional to the force acting on the object.
 - opposite to the direction of force, with acceleration proportional to the mass of the object.

- (iii) in the direction of force, with acceleration inversely proportional to the force acting on the object.
- (iv) in the direction of force, with acceleration proportional to the force acting on the object.

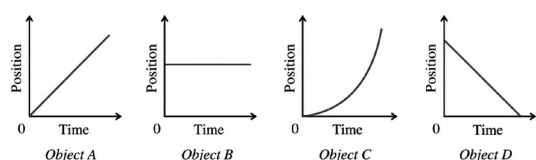
Ans :

Option (iv) is correct.

According to Newton's second law of motion, the acceleration of an object is in the direction of the net force and its magnitude is directly proportional to the net force applied.

6. The position-time graph for four objects A, B, C and D moving along a straight line are given in Figure. A net force acts on:

- (i) Object A
- (ii) Object B
- (iii) Object C
- (iv) Object D



Ans :

Option (iii) is correct.

Object C has a curved position-time graph, indicating that its velocity is changing over time. A changing velocity means the object is accelerating, which requires a net force to be acting on it.

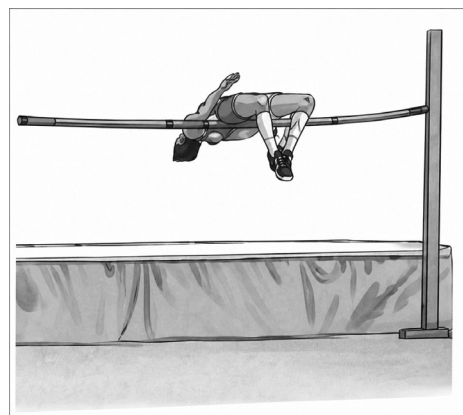
7. A sailor jumps out from a small boat to the shore (Fig). As the sailor jumps forward, will the boat move? If yes, in which direction and why.



Ans :

Yes, the boat will move backward, away from the shore. According to Newton's third law of motion, as the sailor pushes the boat backward with their feet to jump forward, the boat exerts an equal and opposite force forward on the sailor. This backward force applied by the sailor causes the boat to move in the reverse direction.

8. During a high jump event, a landing mat or sand bed is placed for the athlete to fall upon (Figure). Explain the reason behind it.



Ans :

The landing mat or sand bed provides a soft, compressible surface that increases the time it takes for the falling athlete to come to a complete stop. According to Newton's second law of motion, force is equal to the rate of change of momentum. By extending the stopping time, the rate of change of momentum decreases, which significantly reduces the impact force exerted on the athlete's body, thereby preventing serious injuries.

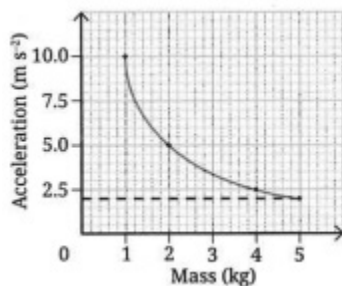
9. A hand cart loaded with vegetables collides with an identical but empty hand cart. During the collision:
- (i) the loaded cart exerts a force of larger magnitude on the empty cart.
 - (ii) the empty cart exerts a force of larger magnitude on the loaded cart.
 - (iii) neither cart exerts a force on the other.
 - (iv) the loaded cart and the empty cart, both exert an equal magnitude of force on each other.

Ans :

Option (iv) is correct.

Newton's third law of motion states that for every action, there is an equal and opposite reaction; hence, regardless of their different masses, both carts exert an equal magnitude of force on each other during the collision.

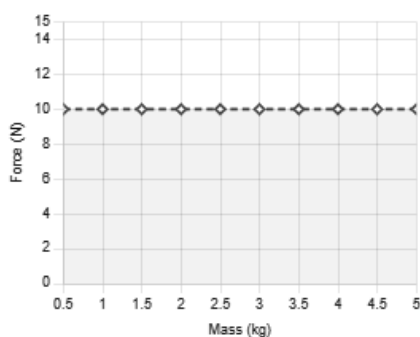
10. The acceleration-mass graph for the acceleration produced by a force on objects of different masses is plotted in Figure Plot the force-mass graph for this case.



Ans :

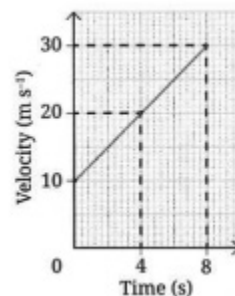
From the given graph, as mass increases the acceleration decreases (inverse relationship). Reading key data points from the curve:

Mass, m (kg)	Acceleration, a (ms ⁻²)	Force, F = ma (N)
1	10	10
2	5	10
4	2.5	10



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11. The velocity-time graph of an object of mass 10 kg moving along a straight line is shown in figure . Calculate the force acting on the object by using the graph.



Ans :

From the given graph,
The initial velocity (u) at time t = 0 is 10 m/s,
and the final velocity (v) at time t = 8 s is 30 m/s.

The acceleration (a) using the formula

$$a = (v - u) / t.$$

$$a = (30 \text{ m/s} - 10 \text{ m/s}) / 8 \text{ s}$$

$$= 20 / 8 = 2.5 \text{ m/s}^2.$$

Using Newton's second law,

$$\text{Force (F)} = \text{mass (m)} \times \text{acceleration (a)}$$

$$F = 10 \text{ kg} \times 2.5 \text{ m/s}^2 = 25 \text{ N}.$$

The force acting on the object is 25 N.

12. A bullet of mass 50 g moving with a speed of 100 ms^{-1} enters a heavy stationary wooden block and stops after penetrating a distance of 50 cm. Estimate the stopping force acting on the bullet (assume that the bullet undergoes constant acceleration within the block).

Ans :

Given

Mass of the bullet (m) = 50 g = 0.05 kg

Initial velocity (u) = 100 m/s

Final velocity (v) = 0 m/s (since it stops)

Distance (s) = 50 cm = 0.5 m

Using the kinematic equation

$$v^2 - u^2 = 2as:$$

$$0^2 - (100)^2 = 2 \times a \times 0.5$$

$$-10000 = 1 \times a$$

$$\text{Acceleration (a)} = -10000 \text{ m/s}^2$$

Now, calculating the force using

$$F = ma:$$

$$F = 0.05 \text{ kg} \times (-10000 \text{ m/s}^2) \\ = -500 \text{ N}.$$

The estimated stopping force acting on the bullet is 500 N, acting opposite to its direction of motion.

- 13.** An ace footballer converted a penalty shot by kicking the football with a speed of 108 km h^{-1} . The estimated force they imparted was 800 N. The mass of the football was 0.4 kg. Calculate the time of contact between their foot and the ball.

Ans :

$$\text{Final velocity (v)} = 108 \text{ km/h} \\ = 108 \times (5/18) \text{ m/s} \\ = 30 \text{ m/s}.$$

Assuming the ball started from rest,

$$\text{initial velocity (u)} = 0 \text{ m/s}.$$

$$\text{Force (F)} = 800 \text{ N}$$

$$\text{Mass (m)} = 0.4 \text{ kg}$$

Using Newton's second law to find acceleration (a):

$$F = ma,$$

$$\text{so } a = F/m \\ = 800/0.4 \\ = 2000 \text{ m/s}^2$$

Now, using the equation $v = u + at$, we get

$$30 = 0 + 2000 \times t \\ t = 30/2000 \\ = 0.015 \text{ s}.$$

The time of contact between the foot and the ball is 0.015 seconds.

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- 14.** An object of mass 2 kg moving with a constant velocity of 10 m s^{-1} encounters a rough patch where the force of friction on the object is 7 N. At the same time, an additional constant force of 3 N opposing the motion is applied on the object. After entering the rough patch, how much distance does the object travel before coming to rest?

Ans :

Given

$$\text{Mass } m = 2 \text{ kg}$$

$$\text{Initial velocity } u = 10 \text{ ms}^{-1}$$

$$\text{Final velocity } v = 0 \text{ ms}^{-1} \quad (\text{comes to rest})$$

$$\text{Force of friction } f = 7 \text{ N} \quad (\text{opposing motion})$$

Additional opposing force

$$F = 3 \text{ N} \quad (\text{opposing motion})$$

Net Force on the Object

Both forces act opposite to the direction of motion - they add up.

$$F_{\text{net}} = -(f + F) \\ = -(7 + 3) = -10 \text{ N}$$

$$F_{\text{net}} = -10 \text{ N (opposing motion)}$$

Acceleration of the Object

Using Newton's Second Law:

$$a = F_{\text{net}}/m$$

$$a = \frac{-10}{2}$$

$$a = -5 \text{ ms}^{-2} \quad (\text{deceleration})$$

Distance Travelled Before Coming to Rest

Using the equation of motion:

$$v^2 = u^2 + 2as$$

$$s = \frac{v^2 - u^2}{2a}$$

$$s = \frac{0^2 - 10^2}{2 \times (-5)} = \frac{-100}{-10}$$

$$s = 10 \text{ m}$$

- 15.** A tractor pulls a harrow (a ploughing tool) of mass m_1 with a net force F resulting in an acceleration of a_1 . The same tractor pulls a trolley of mass m_2 with a force F producing an acceleration of a_2 . If the tractor now pulls the trolley with the harrow placed on it (with the same force F), then obtain an expression for the resulting acceleration in terms of a_1 and a_2 . Ignore friction.

Ans :

From Newton's second law, for the harrow:

$$m_1 = F/a_1$$

$$\text{For the trolley: } m_2 = F/a_2$$

When they are pulled together, the combined mass is $m = m_1 + m_2$.

Substituting the values of m_1 and m_2 :

$$\begin{aligned} m &= (F/a_1) + (F/a_2) \\ &= F(1/a_1 + 1/a_2) \\ &= F[(a_1 + a_2)/(a_1 \times a_2)] \end{aligned}$$

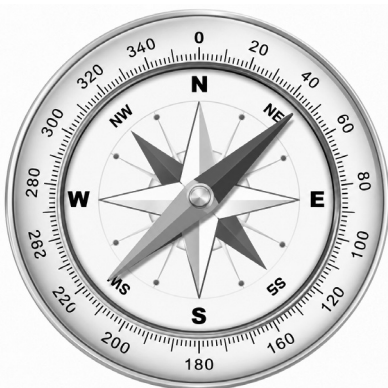
The resulting acceleration (a) when force F is applied to this combined mass is:

$$\begin{aligned} a &= F/m \\ a &= F/\{F[(a_1 + a_2)/(a_1 \times a_2)]\} \end{aligned}$$

The F cancels out, leaving:

$$a = (a_1 \times a_2)/(a_1 + a_2)$$

16. When the pole of a bar magnet is brought close to a magnetic compass, the bar magnet and the compass needle (which is also a magnet) exert a magnetic force on each other. As per Newton's third law of motion, both the forces are equal in magnitude and opposite in direction. However, the compass needle moves, whereas the bar magnet does not move. Explain why.



Ans :

Even though the forces acting on both the bar magnet and the compass needle are equal in magnitude, their effects are very different due to their masses. According to Newton's second law, acceleration is inversely proportional to mass ($a = F/m$). The compass needle has a very tiny mass, so the magnetic force causes a large, noticeable acceleration. In contrast, the bar magnet is significantly heavier, so the same magnitude of force produces an acceleration that is too small to be noticed, and often not enough to overcome the force of static friction holding it in place.

OBJECTIVE QUESTIONS

1. Which of the following physical quantities is required to completely specify a force acting on an object?
- Magnitude only
 - Direction only
 - Both magnitude and direction
 - Neither magnitude nor direction

Ans : (C)

Force is a physical quantity that requires both magnitude and direction for its complete description. If either the magnitude or the direction of the applied force changes, the overall effect on the object also changes. Therefore, force is classified as a vector quantity, unlike scalar quantities which only have magnitude and no specific direction associated with them.

2. What is the standard SI unit of force as established in scientific measurement?
- Joule
 - Newton
 - Pascal
 - Watt

Ans : (B)

The standard international unit of force used in physics is the newton, which is symbolised by a capital letter N. This unit is named after the scientist Sir Isaac Newton. The magnitude of force applied on an object expresses its overall strength and determines the resulting acceleration produced in the object according to the second law.

3. Consider a scenario where two teams are playing a game of tug of war. If both teams pull the rope in opposite directions with equal force, what will be the state of the rope?
- It moves towards the team with more players
 - It moves upwards due to tension
 - It does not move at all
 - It breaks immediately in the middle

Ans : (C)

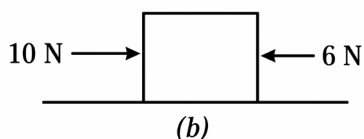
In a game of tug of war, when both teams pull the rope with equal force in opposite directions, the net force acting on the rope becomes exactly zero. These equal and opposite forces are called balanced forces. Because the forces are perfectly balanced, the rope does not move and remains in its initial state of rest.

4. Two forces of 15 N and 10 N act on a wooden block resting on a table. If both forces are applied in the exact same direction, what is the magnitude of the net force acting on the block?
- (A) 5 N
(B) 10 N
(C) 15 N
(D) 25 N

Ans : (D)

When two or more forces are applied simultaneously on an object in the same direction, their individual magnitudes add up to provide the total effective force. In this specific case, adding the applied force of fifteen newtons and ten newtons yields a combined net force of twenty-five newtons acting in the direction of the initial application.

5. Determine the magnitude and the direction of the net force acting on the block shown in the diagram.



- (A) 16 N towards the left side
(B) 16 N towards the right side
(C) 4 N towards the left side
(D) 4 N towards the right side

Ans : (D)

The forces act in opposite directions along the same line. The net force is the difference between their individual magnitudes, which calculates to exactly four newtons. The direction of the resultant net force is fundamentally determined by the larger applied force, which clearly points towards the right side of the block.

6. Two individuals apply forces of 20 N and 12 N in directly opposite directions on a heavy box. What is the magnitude and direction of the net force?
- (A) 32 N in the direction of the 20 N force
(B) 8 N in the direction of the 20 N force
(C) 8 N in the direction of the 12 N force
(D) 32 N in the direction of the 12 N force

Ans : (B)

When two unbalanced forces act on an object in completely opposite directions, the net force is

determined by calculating the difference between their respective magnitudes. Here, twenty minus twelve equals eight newtons. This resulting net force always acts in the direction of the larger applied force, causing the object to accelerate in that specific direction.

7. Consider the following statements regarding the effects of force on an object:

1. It can change the state of rest of an object.
2. It can change the direction of motion of an object.
3. It can change the shape of an object.

Which of the above statements are correct?

- (A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2, and 3

Ans : (D)

An applied external force has the physical capability to alter the state of motion of a body from rest, change its velocity or direction while moving, and even deform its structural shape. Examples include kicking a stationary ball, hitting a moving cricket ball with a bat, and squeezing a lemon, demonstrating all these fundamental physical effects clearly.

8. When you push a heavy wooden box placed on a rough horizontal floor, it does not move immediately. Which specific force acts in the direction opposite to your push to prevent the motion?

- (A) Gravitational force
(B) Buoyant force
(C) Force of friction
(D) Normal force

Ans : (C)

The force of friction is a contact force that always arises between two surfaces trying to slide past one another. It consistently acts in a direction completely opposite to the direction of the applied force or intended motion. The box remains stationary until the applied pushing force eventually exceeds this opposing maximum static frictional force.

9. In a classroom activity, a stack of coins is pulled with a rubber band across different horizontal surfaces. On which of the following surfaces will the stack of coins travel the greatest distance before coming to rest?
- A rough cemented floor
 - A highly polished marble floor
 - A laminated wooden table top
 - A carpeted floor

Ans : (B)

The magnitude of frictional force fundamentally depends heavily upon the relative smoothness or roughness of the interacting surfaces. A highly polished marble floor offers the least possible resistance among the given options. Consequently, the opposing frictional force is minimised, allowing the moving stack of coins to travel a significantly larger distance before gradually coming to rest.

10. A student measures the horizontal forces acting on four different wooden blocks placed on a table. The blocks are being pushed to the right, while the frictional force acts to the left. Based on the data in the table, which block will move with a constant velocity?

Block	Applied Force to the Right (N)	Frictional Force to the Left (N)	Initial State
Block W	15	10	Moving
Block X	20	20	Moving
Block Y	12	12	At rest
Block Z	10	15	Moving

- Block W
- Block X
- Block Y
- Block Z

Ans : (B)

Constant velocity occurs when the net force acting on a moving object is zero. For Block X, the applied force and frictional force are perfectly balanced at twenty Newtons each, resulting in zero net force. Since it is already moving, it will continue to move uniformly without accelerating or decelerating.

11. Who among the following historical scientists first argued through a series of thought experiments that if all impediments to motion are removed,

a body moving along a horizontal plane will continue to move indefinitely?

- Isaac Newton
- Albert Einstein
- Galileo Galilei
- Johannes Kepler

Ans : (C)

In the seventeenth century, Galileo Galilei radically proposed through extensive thought experiments that objects in motion do not naturally require a continuous applied force to keep moving. He argued that if opposing forces like friction were completely eliminated, a body moving on a perfectly horizontal plane would persist in its uniform motion indefinitely without ever stopping.

12. **Assertion (A):** An object moving with a constant velocity on a horizontal surface has a net zero force acting upon it.

Reason (R): The force of friction acting on the object is exactly balanced by the external applied force.

- Both A and R are true and R is the correct explanation of A
- Both A and R are true but R is not the correct explanation of A
- A is true but R is false
- A is false but R is true

Ans : (A)

According to the first law of motion, an object maintains a constant velocity only when the overall net external force acting on it is zero. To achieve this constant velocity in reality, a continuous external forward force must be applied that precisely equals and cancels out the backward opposing frictional force, rendering the net force zero.

13. Read the following statements related to Newton's first law of motion:

- It is also known as the law of inertia.
- It states that an object changes its velocity even if net force is zero.
- It explains the tendency of objects to resist a change in their state.
- An object at rest has an acceleration of zero.

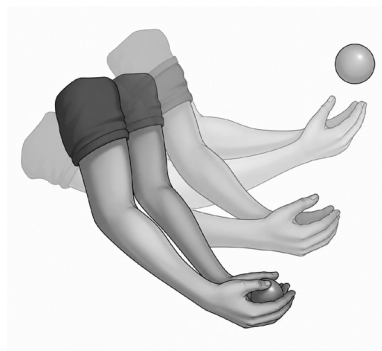
Which of the above statements are correct?

- 1, 2, and 3
- 1, 3, and 4
- 2, 3, and 4
- 1, 2, and 4

Ans : (B)

The first law of motion formally describes inertia, which is the natural tendency of physical objects to stubbornly resist any change in their current state of rest or uniform motion. An object at rest possesses zero acceleration. However, if the net external force is zero, the velocity remains absolutely constant and cannot change under any circumstances.

14. A fielder pulls his hands backward while catching a fast-moving cricket ball, as shown in the diagram. What is the primary physical principle utilized in this specific action to prevent injury?



- (A) Decreasing the change in velocity of the ball to perfectly reduce the impact force.
 (B) Increasing the time duration of the catch to strategically reduce the ball's acceleration.
 (C) Increasing the mass of the catching system to physically absorb the ball's momentum.
 (D) Applying an unbalanced contact force in the direction of the ball's initial motion.

Ans : (B)

By pulling the hands backward, the fielder effectively increases the time duration over which the high velocity of the ball reduces to zero. This deliberately decreases the magnitude of acceleration, requiring a considerably smaller opposing force to stop the ball, thereby minimizing the dangerous impact and preventing painful physical injury.

15. If the net external force acting on a moving car is entirely zero, what will be the shape of its position-time graph?
 (A) A straight line parallel to the time axis
 (B) A straight line parallel to the position axis
 (C) A straight inclined line passing through the origin
 (D) A continuous parabolic curve

Ans : (C)

When the net external force on an object is zero, it completely maintains a uniform and constant velocity. On a standard position-time graph, uniform velocity is mathematically represented by a straight line inclined continuously to the time axis. A line parallel to the time axis would incorrectly indicate an object that is entirely stationary at rest.

16. Which mathematical equation correctly represents Newton's second law of motion relating force, mass, and acceleration?

- (A) $F = m/a$
 (B) $F = m + a$
 (C) $F = ma$
 (D) $F = a/m$

Ans : (C)

Newton's second law of motion mathematically establishes that the net external force acting upon an object is equal to the product of its mass and its resulting acceleration. This fundamental relationship is universally expressed by the simple algebraic formula $F = ma$, indicating that applied force is directly proportional to the acceleration produced in the mass.

17. Four identical toy cars are set in motion on different surfaces. The table records their initial velocity and the total net force acting upon them. Which car will produce a position-time graph that is a straight line inclined to the time axis?

Car	Initial Velocity (m/s)	Net Force (N)
Car P	0	0
Car Q	5	2
Car R	4	0
Car S	3	-1

- (A) Car P
 (B) Car Q
 (C) Car R
 (D) Car S

Ans : (C)

A straight line inclined to the time axis on a position-time graph indicates uniform motion with a constant, non-zero velocity. According to Newton's first law, an object maintains its constant velocity only when the net force acting on it is zero. Car R is initially moving and experiences zero net force.

18. One newton of force is formally defined as the specific amount of force required to produce:
- (A) An acceleration of 1 ms^{-2} on an object of mass 1 g
 - (B) A velocity of 1 ms^{-1} on an object of mass 1 kg
 - (C) An acceleration of 1 ms^{-2} on an object of mass 1 kg
 - (D) A uniform motion on an object of mass 10 kg

Ans : (C)

Using the established formula $F = ma$, if the mass of an object is one kilogram and the resulting acceleration is one metre per second squared, the required force is calculated exactly as one newton. Therefore, one newton is officially defined as the precise force that accelerates a one-kilogram mass by one metre per second squared.

19. Match the physical quantities in List-I with their corresponding SI units in List-II.

	List-I (Physical Quantity)		List-II (SI Unit)
P.	Force	1.	ms^{-1}
Q.	Mass	2.	kg
R.	Acceleration	3.	N
S.	Velocity	4.	ms^{-2}

- (A) P-3, Q-2, R-4, S-1
- (B) P-3, Q-2, R-1, S-4
- (C) P-2, Q-3, R-4, S-1
- (D) P-4, Q-2, R-3, S-1

Ans : (A)

In the International System of Units, force is measured in newtons to quantify pushes or pulls. Mass is consistently measured in kilograms to indicate inertia. Acceleration is measured in metres per second squared to show velocity change rate. Finally, velocity is strictly measured in metres per second to represent the rate of displacement over time.

20. A constant force acts on an object of mass 5 kg, resulting in an acceleration of 4 ms^{-2} . Calculate the magnitude of the applied force.
- (A) 1.25 N
 - (B) 9 N
 - (C) 20 N
 - (D) 100 N

Ans : (C)

To accurately calculate the magnitude of the applied force, we must utilise Newton's second law of motion, applying the standard formula $F = ma$. By substituting the given values into the equation, we multiply the mass of five kilograms by the acceleration of four metres per second squared, which correctly yields a total force of twenty newtons.

21. In a game of cricket, a fielder gradually pulls his hands backwards alongside the moving ball while catching it. What is the scientific purpose of this specific action?
- (A) To increase the final velocity of the ball
 - (B) To increase the time duration of stopping the ball
 - (C) To decrease the time duration of stopping the ball
 - (D) To increase the total momentum of the ball

Ans : (B)

By deliberately pulling their hands backwards, the fielder successfully increases the total time duration over which the high velocity of the cricket ball reduces to zero. According to the second law of motion, extending this stopping time dramatically decreases the magnitude of acceleration, which sequentially reduces the impact force and significantly minimises potential injury to hands.

22. **Assertion (A):** Modern vehicles are equipped with inflatable airbags to protect passengers during severe sudden collisions.
- Reason (R):** Airbags rapidly decrease the time over which a passenger's forward motion is halted.
- (A) Both A and R are true and R is the correct explanation of A
 - (B) Both A and R are true but R is not the correct explanation of A
 - (C) A is true but R is false
 - (D) A is false but R is true

Ans : (C)

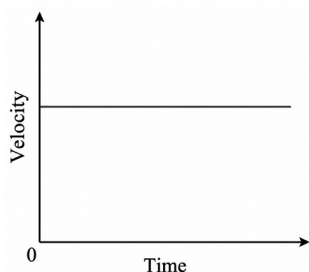
The primary assertion is factually correct because airbags provide essential safety during crashes. However, the stated reason is entirely false. Airbags function effectively by increasing, not decreasing, the total time over which the passenger's sudden deceleration occurs. This crucial time extension successfully reduces the overall impact force exerted on the person, thereby preventing severe traumatic injuries.

23. A student pushes a stationary 20 kg block on a floor. The maximum force of friction opposing this motion is 40 N. If the student applies a constant forward force of 60 N, what is the acceleration of the block?
- (A) 1 ms^{-2}
 (B) 2 ms^{-2}
 (C) 3 ms^{-2}
 (D) 5 ms^{-2}

Ans : (A)

The net forward force determining motion is the applied force minus the opposing frictional force. Subtracting forty newtons from sixty newtons leaves a net force of exactly twenty newtons. Using the formula $F = ma$, we calculate acceleration by dividing this net twenty newtons by the mass of twenty kilograms, resulting in exactly one metre per second squared.

24. The given velocity-time graph represents the uniform motion of a sliding object. What can be directly concluded about the net force acting on this object?



- (A) A constant non-zero net force acts in the direction of motion.
 (B) A continuously increasing net force acts upon the moving object.
 (C) The net external force acting on the object is exactly zero.
 (D) A net force acts in the direction opposite to its general motion.

Ans : (C)

The velocity-time graph displays a horizontal straight line parallel to the time axis, indicating that the object moves with a constant velocity. According to Newton's first law of motion, an object strictly maintains a constant velocity and zero acceleration only when the net external force acting upon it is identically zero.

25. An object of mass 10 kg initially at rest is subjected to a constant net force of 50 N. What

will be its velocity after exactly 4 seconds?

- (A) 5 ms^{-1}
 (B) 10 ms^{-1}
 (C) 20 ms^{-1}
 (D) 40 ms^{-1}

Ans : (C)

First, calculate the acceleration using the second law of motion formula $a = F/m$. Dividing fifty newtons by ten kilograms yields an acceleration of five metres per second squared. Using the kinematic equation $v = u + at$ with zero initial velocity, multiplying five by four seconds perfectly gives a final velocity of twenty metres per second.

26. According to Newton's third law of motion, whenever a primary object completely exerts a force on a secondary object, the secondary object always:
- (A) Exerts a slightly lesser opposing force on the primary object
 (B) Exerts an equal and opposite force simultaneously on the primary object
 (C) Exerts a larger and opposite force delayed in time
 (D) Accelerates exactly at the same rate regardless of its mass

Ans : (B)

Newton's third law of motion fundamentally establishes that forces strictly occur in interacting pairs. Whenever object A exerts a defined force upon object B, object B must simultaneously exert a force of completely equal magnitude but in the exact opposite direction upon object A. These paired forces are simultaneous and define the concept of action and reaction.

27. If action and reaction forces are always exactly equal in magnitude and opposite in direction, why do they not simply cancel each other out to produce zero net force?
- (A) Because action forces are naturally stronger than reaction forces
 (B) Because they always act simultaneously on two completely different objects
 (C) Because they act sequentially on the same individual object
 (D) Because the objects invariably possess vastly different physical masses

Ans : (B)

Although action and reaction forces are completely equal and opposite in magnitude,

they do not mathematically cancel each other out to zero because they consistently act upon two entirely different objects. For a net force on a single body to be fundamentally calculated, only the specific individual forces acting directly upon that singular body are systematically considered.

- 28. Assertion (A):** When a person walks forward on a rough road, the road pushes the person forward.

Reason (R): The person pushes the ground backward with their foot, and the ground exerts an equal and opposite force of friction forward.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The fundamental mechanics of walking heavily rely upon the precise application of Newton's third law. As a person attempts to move, their foot deliberately pushes the solid ground backwards. In immediate response, the ground applies an equal and opposing forward frictional force directly onto the foot. This reactive external force is what successfully propels the person forward.

- 29.** A group of students conducted an experiment using a cart and a pulley system to study the relationship between force, mass, and acceleration. They recorded their observations in the table but left one value missing. What is the exact mass of the cart in Trial 4 ?

Trial	Mass of the Cart (kg)	Net Force Applied (N)	Acceleration Produced (m/s^2)
Trial 1	2.0	10.0	5.0
Trial 2	4.0	10.0	2.5
Trial 3	2.0	20.0	10.0
Trial 4	M	12.0	3.0

- (A) 2.0 kg
 (B) 3.0 kg
 (C) 4.0 kg
 (D) 6.0 kg

Ans : (C)

According to Newton's second law of motion, the net force acting on an object is equal to the product of its mass and acceleration. By rearranging the

formula to solve for mass, we divide the net force by the acceleration. For the fourth trial, dividing twelve Newtons by three yields four kilograms.

- 30.** While rowing a small wooden canoe in a lake, how does the canoeist successfully propel the boat in the forward direction?
 (A) By pushing the surrounding air backward with their bodily movement
 (B) By pulling the water directly forward with the paddle blade
 (C) By pushing the water backward with the paddle, causing water to push the paddle forward
 (D) By constantly shifting their bodily weight towards the front of the canoe

Ans : (C)

When a canoeist forcefully pushes the paddle backward against the dense water, it constitutes an action force. According to Newton's third law, the water instantly exerts an equal and directly opposite reaction force onto the paddle in the forward direction. This specific forward reactive force applied to the paddle is what effectively moves the entire canoe forward.

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- 31.** During the launching phase of a heavy space rocket, what provides the crucial upward thrust required to overcome Earth's gravitational pull?
 (A) The physical pushing of the rocket's metallic base against the launch pad
 (B) The intense downward expulsion of hot exhaust gases from the engine
 (C) The rapid upward movement of atmospheric air around the rocket body
 (D) The sudden internal combustion of fuel pushing upward on the nose cone

Ans : (B)

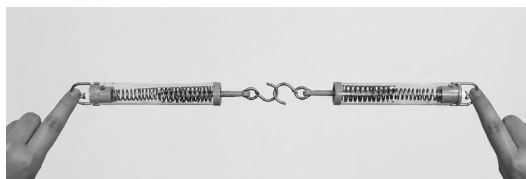
A space rocket operates strictly on the principle of Newton's third law. The powerful engines expel high-velocity hot exhaust gases forcefully downward toward the ground. This forceful downward expulsion constitutes an action. In immediate response, the expelled gases exert an equal and opposite massive reaction force upward upon the rocket, successfully providing the necessary lifting thrust.

32. When a small bullet of mass 0.05 kg is fired from a large gun of mass 4 kg with a forward force of 100 N, what is the magnitude of the initial recoil acceleration of the gun?
- (A) 10 ms^{-2}
 (B) 25 ms^{-2}
 (C) 2000 ms^{-2}
 (D) 400 ms^{-2}

Ans : (B)

According to the third law, the gun experiences a backward recoil force equal to the bullet's forward force, exactly one hundred newtons. To accurately determine the gun's resulting acceleration, we divide this one hundred newton force by the gun's total mass of four kilograms using the formula $a = F/m$. This calculation strictly yields twenty-five metres per second squared.

33. Two identical spring balances are hooked together and pulled in opposite directions. If the person on the left pulls with a force of 15 N, what will be the reading on the right spring balance?



- (A) 0 N, because the two opposing mechanical forces cancel each other out completely.
 (B) 30 N, because the combined tension forces add up across the interacting system.
 (C) 15 N, because every action force actively produces an equal and opposite reaction force.
 (D) 7.5 N, because the total applied force distributes equally between the two internal springs.

Ans : (C)

The interacting spring balances exert pulling forces upon each other. According to Newton's third law of motion, whenever one object exerts a force on a second object, the second object simultaneously exerts an equal and opposite force. Therefore, both connected spring balances will constantly record the exact same fifteen-newton magnitude.

34. When a swollen balloon is suddenly untied and the trapped air rushes out horizontally to the left, in which direction will the rubber balloon initially

move?

- (A) Upwards
 (B) Downwards
 (C) Horizontally to the left
 (D) Horizontally to the right

Ans : (D)

The stretched rubber material forcefully pushes the trapped air horizontally to the left, effectively acting as an action force. Following Newton's third law, the escaping rushing air exerts an equal and entirely opposite reaction force directly onto the balloon itself. Consequently, this reaction force propels the balloon strongly in the opposite horizontal direction, which is precisely towards the right.

35. Arrange the following sequence of events accurately to explain how a large ship is safely stopped using a thick pier rope:

1. The thick rope strongly grips the wooden post tightly.
 2. The massive ship forcefully pulls on one end of the rope.
 3. The opposing friction between the rough rope and post massively increases.
 4. The rope is repeatedly wrapped tightly around a stationary post.
- (A) 4, 2, 1, 3
 (B) 2, 4, 3, 1
 (C) 4, 2, 3, 1
 (D) 1, 2, 4, 3

Ans : (A)

To safely secure a massive moving ship, a strong rope is first wrapped repeatedly around a sturdy post. When the moving ship initially pulls the rope, the multiple tight wraps tightly grip the post. This sequential gripping rapidly increases the effective surface friction exponentially. Consequently, this immensely enhanced friction successfully provides the massive holding force required.

36. Select the correct sequential order of physical steps required to determine the overall mass of an interconnected system of two moving boxes:

1. Divide the calculated net external force by the measured systemic acceleration.
2. Carefully observe and measure the common acceleration of the moving system.
3. Treat the two connected boxes solely as a single unified moving system.

4. Accurately identify and measure the net external applied force pushing the system.

(A) 3, 4, 2, 1
(B) 4, 3, 1, 2
(C) 3, 2, 4, 1
(D) 2, 3, 4, 1

Ans : (A)

To analyse connected physical bodies systematically, you must first treat them conceptually as a single unified system. Next, identify the total external force acting upon it, followed by carefully measuring the resulting common acceleration of the group. Finally, utilizing Newton's second law mathematically, divide the total external force by the acceleration to find total mass.

- 37.** Match the real-life physical scenarios in List-I with the most appropriate scientific principle explaining them in List-II.

	List-I (Scenario)		List-II (Principle)
P.	A book resting peacefully on a table	1.	Newton's third law of motion
Q.	A fast car slowing down forcefully	2.	Reducing acceleration by increasing time
R.	A swimmer pushing water vigorously	3.	Balanced forces resulting in zero net force
S.	Airbags inflating instantly during impact	4.	Net force opposing the motion

(A) P-3, Q-4, R-1, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

Ans : (A)

A resting book perfectly demonstrates balanced forces. A rapidly decelerating car experiences an opposing net frictional force. A swimmer purposefully pushing water effectively utilises the strict action-reaction pairs of the third law. Finally, airbags provide crucial safety strictly by increasing impact time, which proportionally decreases harmful stopping acceleration according to the second law of motion.

- 38.** When treating two wooden boxes connected by a tight string as a single moving physical system, which of the following internal forces is completely ignored during net calculation?

(A) The external applied pushing force
(B) The tension force acting within the tight string
(C) The downward gravitational pull on the boxes
(D) The upward normal force from the flat floor

Ans : (B)

When scientists treat multiple connected physical objects as one singular system, the internal forces actively acting between the individual parts strictly cancel each other out internally. The tension heavily present within the connecting string constitutes an internal force pair. Therefore, it is completely ignored when calculating the overall external acceleration of the entire combined physical system.

- 39.** The uniform acceleration caused by Earth's gravitational force acting upon falling objects is generally denoted by g . What is its approximate standard value near Earth's surface?

(A) 1.6 ms^{-2}
(B) 9.8 ms^{-2}
(C) 15.5 ms^{-2}
(D) 32.0 ms^{-2}

Ans : (B)

When an object naturally falls solely under the direct influence of Earth's gravity, it experiences a constant downward acceleration specifically known as acceleration due to gravity. The accepted standard numerical value for this acceleration uniformly near the surface of the Earth is measured at approximately nine point eight metres per second squared, irrespective of mass.

- 40.** Consider the following specific statements regarding fundamental non-contact forces:

- Two closely placed bar magnets can apply equal and opposite magnetic forces.
- Two similarly charged objects repel with unequal electrostatic forces.
- The Earth and a falling fruit exert equal gravitational forces upon each other.

Which of the above statements are strictly correct?

(A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 1, 2, and 3

- (A) A massive single forward external force is heavily acting
- (B) The total external net applied force is fundamentally zero
- (C) The deep internal block mass must strictly be absolutely zero
- (D) The opposing friction completely exceeds the forward pulling force

Ans : (B)

Based firmly upon strict Newton's second fundamental law ($F = ma$), if the carefully calculated resulting acceleration mathematically equals absolutely zero, then the total external applied net force must also undeniably be precisely zero, assuming total mass exists. This fundamentally means all forward and backward opposing active forces are entirely balanced perfectly against each other.

VERY SHORT ANSWER

- 66.** What is meant by the physical quantity called force?

Ans :

Force is a physical quantity that can make an object move from rest, change its speed, direction of motion, or change its shape completely.

- 67.** What is the SI unit of force and how is it correctly written?

Ans :

The SI unit of force is newton, which is written starting with a small letter 'n', and its capital symbol is denoted as 'N'.

- 68.** Which instrument is commonly used to measure the magnitude of a force?

Ans :

A spring balance is the instrument commonly used to measure the magnitude of a force, including the gravitational force acting on an object.

- 69.** State one crucial characteristic required to completely specify a force acting on an object.

Ans :

To specify a force completely, one must state its direction along with its magnitude, because force is a physical quantity possessing both these characteristics.

- 70.** Define balanced forces acting on an object.

Ans :

Balanced forces are two or more forces applied on an object that are equal in magnitude but opposite in direction, producing zero net force.

- 71.** What is the result when unbalanced forces act on a stationary object?

Ans :

When unbalanced forces act on a stationary object, a non-zero net force causes the object to move in the direction of the larger force.

- 72.** How do you calculate the net force when two unequal forces act in opposite directions?

Ans :

The magnitude of the net force equals the difference between the magnitudes of the two forces, acting in the direction of the larger force.

- 73.** What causes a moving bicycle to eventually stop when you stop pedalling it?

Ans :

The bicycle stops due to the force of friction arising between the tyres and the road surface, acting opposite to its direction of motion.

- 74.** What would you observe about an object's velocity if it moves on a frictionless horizontal surface?

Ans :

On a completely frictionless horizontal surface with no other impediments, the object's velocity would not decrease, and it would continue to move indefinitely forever.

- 75.** Who first proposed the idea that objects tend to resist changes in their state of motion?

Ans :

Isaac Newton used the word inertia to describe this tendency of objects, building upon the earlier thought experiments conducted by scientist Galileo Galilei.

- 76.** State Newton's first law of motion.

Ans :

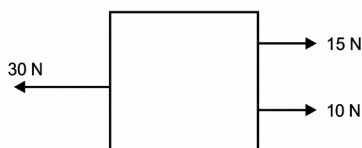
An object at rest remains at rest, and an object in motion continues with constant velocity, unless a net force acts upon the object.

- (A) The Earth exerts a massively larger gravitational force on the fruit than vice versa.
- (B) The net unbalanced force acting on the massive Earth is entirely zero during the fall.
- (C) The interacting forces are equal, but the heavily massive Earth experiences negligible acceleration.
- (D) Gravity behaves strictly as an unbalanced contact force selectively on the lighter falling object.

Ans : (C)

Both bodies exert equal and opposite gravitational forces on each other, strictly satisfying Newton's third law. However, according to Newton's second law, acceleration is inversely proportional to an object's mass. Because the Earth's mass is extraordinarily large compared to the fruit, its resulting acceleration is microscopically small and completely unnoticeable.

45. Based on the force vectors acting on the block in the diagram, what is the magnitude and direction of the net force, and how will it affect the block's state of motion?



- (A) 5 N towards the left; the block will accelerate leftward.
- (B) 5 N towards the right; the block will accelerate rightward.
- (C) 25 N towards the left; the block will move with constant velocity.
- (D) 55 N towards the right; the block will remain at rest.

Ans : (A)

The forces pulling the block to the right total 25 N (15 N + 10 N), while the force pulling to the left is 30 N. The unbalanced net force is the difference, 5 N, directed towards the larger force (left). Consequently, the block will accelerate leftward. The other options miscalculate vector sums or directions.

46. Consider the following physical statements concerning friction and continuous motion:

- Friction constantly acts in the same identical direction as the object's motion.
- A completely frictionless smooth surface allows an object to move uniformly forever.
- Once a pushed object moves, no further external force is ever needed on a rough surface.
- Grooves in footwear soles are designed to deliberately increase friction.

Which of these statements are absolutely correct?

- (A) 1 and 3
- (B) 2 and 4
- (C) 1, 2, and 4
- (D) 2, 3, and 4

Ans : (B)

Frictional force strictly opposes motion, making the first statement false. On a theoretically frictionless surface, an object absolutely moves indefinitely, confirming the second statement. On a real rough surface, continuous force is required to counteract continuous friction, making the third false. Finally, footwear grooves deliberately increase necessary friction for safe walking, confirming the fourth statement perfectly.

47. During a physics demonstration, an astronaut with a mass of 100 kg pushes a satellite with a mass of 500 kg in the vacuum of space. The table displays four different proposed scenarios. Which scenario accurately represents the physical quantities according to the fundamental laws of motion?

Scenario	Force on Astronaut (N)	Acceleration of Astronaut (m/s^2)	Force on Satellite (N)	Acceleration of Satellite (m/s^2)
Scenario A	200	2.0	200	0.4
Scenario B	100	1.0	500	1.0
Scenario C	200	0.4	200	2.0
Scenario D	500	5.0	100	0.2

- (A) Scenario A
- (B) Scenario B
- (C) Scenario C
- (D) Scenario D

Ans : (A)

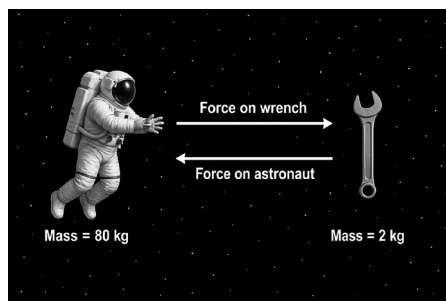
Newton's third law requires interacting objects to exert equal and opposite forces, meaning both experience two hundred Newtons. However, according to the second law, acceleration is

(D) 4, 1, 3, 2

Ans : (A)

To accurately perform this fundamental friction experiment, first, quietly place the wooden block heavily on the testing surface. Next, carefully attach the basic spring balance precisely to the block. After that, gradually apply horizontal forward pulling force. Finally, strictly read the tension scale the exact moment sliding begins, as this precisely indicates maximum static friction.

57. The diagram illustrates an interaction between two objects in the vacuum of deep space. Which statement accurately compares the force magnitudes and the resulting accelerations of the two bodies?



- (A) The astronaut exerts a larger force, causing the wrench to accelerate faster.
 (B) Both experience equal forces, but the wrench experiences greater acceleration.
 (C) Both experience equal forces and will therefore experience equal accelerations.
 (D) The wrench exerts a smaller force, resulting in lower astronaut acceleration.

Ans : (B)

Newton's third law dictates that interacting objects exert equal and opposite forces on each other, meaning both force magnitudes are identical. However, Newton's second law ($a = F/m$) indicates that for the same force, an object with a significantly smaller mass (the 2 kg wrench) will experience a proportionally much greater acceleration than the heavier astronaut.

58. Does Newton's universally celebrated third law of opposite motion mathematically apply properly to invisible non-contact forces like deep magnetic attraction?
- (A) No, it applies strictly only to direct physical contact forces
 (B) Yes, non-contact forces also rigorously act in equal opposite pairs

- (C) No, because invisible magnets entirely lack measurable physical mass
 (D) Yes, but absolutely only within a massive gravitational vacuum field

Ans : (B)

Newton's universally accepted third law correctly governs all known mechanical interactions, regardless of physical proximity. It applies perfectly to both direct contact forces like friction and strictly non-contact invisible forces like heavy magnetic, deep gravitational, and intense electrostatic forces. Interacting bodies fundamentally exert mathematically equal and entirely opposite forces on each other regardless of touching.

59. In a controlled school laboratory experiment, a student repeatedly doubles the total physical mass of a small rolling cart while deliberately maintaining a perfectly constant forward pulling force. What exact physical effect will this actively have on the cart's resulting acceleration?
- (A) The acceleration will instantly double completely.
 (B) The acceleration will drastically remain the same.
 (C) The acceleration will exactly be halved perfectly.
 (D) The acceleration will permanently become absolute zero.

Ans : (C)

Newton's second law definitively dictates that the mathematical magnitude of resulting acceleration is perfectly and inversely proportional strictly to the exact total mass of the accelerating object, provided the applied pulling force remains absolutely constant. Therefore, deliberately doubling the heavy mass essentially forces the resulting physical acceleration to mathematically reduce precisely to exactly one half.

60. The highly profound Newton's second law of physical motion is frequently expressed conceptually in advanced physics strictly in terms of which specific fundamental physical quantity?
- (A) Total energy
 (B) Absolute temperature
 (C) Changing momentum
 (D) Internal volume

Ans : (C)

Ans : (C)

In accordance with Newton's fundamental first law of motion, an object strictly maintains its present state of constant velocity unless actively disturbed by an external unbalanced net force. Since the described horizontal surface is hypothetically completely frictionless and no pulling force is present, the net force is perfectly zero, ensuring the velocity remains totally unchanged indefinitely.

- 53. Assertion (A):** If the total external net force acting directly upon a stationary resting box is definitively zero, the box will firmly remain entirely at rest forever.

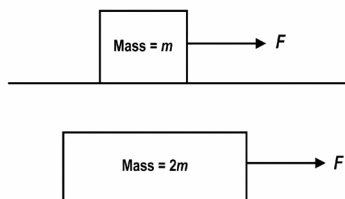
Reason (R): An object at rest fundamentally possesses an absolute velocity of exactly zero, which signifies a constant uniform motion of zero magnitude.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The first law conclusively states that physical objects definitively remain in their precise current state unless forced completely to change. A totally stationary box holds a constant velocity of absolutely zero. Since the external net force is perfectly zero, it entirely lacks the capacity to violently alter this specific zero velocity, thereby remaining stationary forever.

- 54.** Two objects of different masses are subjected to identical pulling forces on a smooth, frictionless surface. Based on the diagram, how does the acceleration of the top object (a_1) compare to the acceleration of the bottom object (a_2)?



- (A) a_1 is equal to a_2
 (B) a_1 is twice a_2
 (C) a_2 is twice a_1

- (D) a_1 is four times a_2

Ans : (B)

Newton's second law expresses that acceleration is inversely proportional to mass for a given constant force ($a = F/m$). The bottom block possesses twice the mass ($2m$) of the top block (m) but experiences the exact same applied force (F). Consequently, the top block will experience an acceleration twice as large as the bottom block.

- 55.** Select the accurate conceptual sequence of physical outcomes strictly resulting when an unbalanced external force is strongly applied to a freely moving object:

1. The moving object completely stops its continuous motion.
2. The initial velocity of the physical object forcefully changes.
3. The net external force aggressively creates a definitive acceleration.
4. The applied net external force initially becomes entirely non-zero.

- (A) 4, 3, 2, 1
 (B) 3, 4, 1, 2
 (C) 4, 2, 3, 1
 (D) 2, 3, 1, 4

Ans : (A)

The precise mechanical sequence strictly begins when an external applied force intentionally causes the net force to violently become non-zero. This unbalanced physical condition strictly creates an immediate acceleration. This sudden acceleration systematically alters the object's current velocity. Ultimately, this intense continuous alteration can forcefully decelerate the moving object until it completely and finally stops.

- 56.** Arrange the following physical steps logically required to experimentally measure the exact opposing frictional force on a rough floor using a basic spring balance:

1. Slowly attach the wooden block to the metallic hook.
2. Read the final tension scale exactly when motion just begins.
3. Place a heavy wooden block quietly on the rough surface.
4. Gradually pull the stretched spring balance horizontally forward.

- (A) 3, 1, 4, 2
 (B) 1, 3, 2, 4
 (C) 3, 4, 1, 2

Ans : (C)

Newton's universal third law perfectly applies to non-contact forces everywhere. Magnets successfully exert completely equal and opposite magnetic forces on each other. Similarly, Earth and a falling fruit strictly apply equal gravitational pulling forces on each other. However, charged objects uniformly exert equal, not unequal, electrostatic forces, making the second proposed statement scientifically incorrect.

41. **Assertion (A):** Even though a falling apple heavily pulls the Earth upwards with an equal gravitational force, the Earth does not visibly move towards the apple.

Reason (R): The immense mass of the Earth results in an extremely negligible upward acceleration.

- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The third law explicitly dictates that the Earth and apple exert exactly identical forces on each other. However, according to the second law ($a = F/m$), acceleration is inversely proportional to mass. Because the Earth's total mass is astonishingly massive compared to the tiny apple, its resulting upward acceleration is infinitely small and completely unnoticeable.

42. An engineer is testing different packaging materials to protect fragile glass items. A glass sphere of fixed mass moving at ten meters per second strikes four different materials and comes to a complete halt. Which material exerts the least impact force on the glass sphere?

Material	Initial Velocity (m/s)	Final Velocity (m/s)	Time to Stop (s)
Bubble wrap	10	0	0.50
Cardboard	10	0	0.10
Sponge foam	10	0	1.20
Thermocol	10	0	0.25

- (A) Bubble wrap
(B) Cardboard
(C) Sponge foam

(D) Thermocol

Ans : (C)

Newton's second law dictates that the force applied is proportional to the rate of change of momentum. Since the change in momentum is identical for all test materials, extending the time duration of the impact reduces the magnitude of the acceleration. Sponge foam takes the longest time, applying the least stopping force.

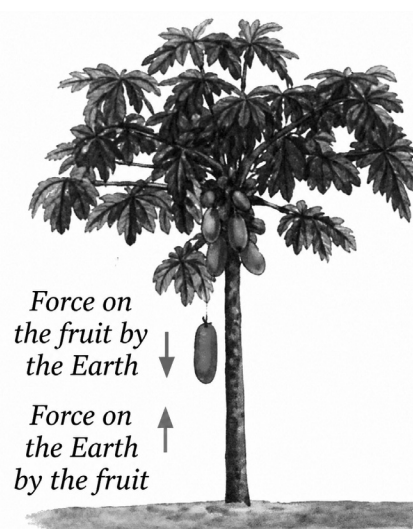
43. Historically, who was the first scientist to clearly use the specific word 'inertia' to comprehensively describe the natural tendency of objects to forcefully resist changes in their motion?

- (A) Galileo Galilei
(B) Albert Einstein
(C) Isaac Newton
(D) Johannes Kepler

Ans : (C)

While Galileo Galilei initially formulated the fundamental idea that moving objects persistently continue moving without friction, it was Sir Isaac Newton who formally introduced and specifically utilised the scientific word 'inertia'. He effectively used this specific term to describe the inherent tendency of objects to resist state changes in his groundbreaking first law of motion.

44. The diagram illustrates the mutual gravitational interaction between the Earth and a falling fruit. Why does the fruit accelerate noticeably downwards, while the Earth's upward acceleration remains physically imperceptible?



While typically learned fundamentally as

$$F = ma,$$

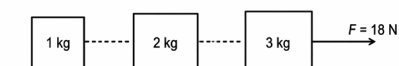
the far more complete and advanced foundational form of Newton's second law is rigorously expressed strictly using momentum. It definitively states that the absolute rate of change of an object's total momentum is mathematically proportional directly to the applied external net force, correctly encompassing variable mass situations.

61. During a high jump sports event, why is a thick soft landing mat strictly placed carefully underneath the falling athlete?
- To violently increase their falling velocity rapidly
 - To entirely eliminate Earth's gravitational pulling force
 - To strictly increase the stopping time thereby drastically reducing impact force
 - To powerfully bounce the falling athlete right back completely upwards

Ans : (C)

When a falling athlete forcefully hits a highly compressible thick soft mat, the deep sinking action radically increases the crucial time duration over which their downward velocity physically stops. According to strict Newton's second law calculations, this extended stopping time drastically reduces the harsh resulting deceleration, which heavily minimizes the dangerous impact force preventing bodily injury.

62. Three blocks are linked by lightweight strings on a smooth, frictionless horizontal table. A single pulling force is applied to the final block in the chain. What is the acceleration of the entire connected system?



- 2 m/s²
- 3 m/s²
- 6 m/s²
- 18 m/s²

Ans : (B)

To calculate the system's acceleration, treat all three interconnected blocks as a single collective mass. The total mass equals 1 kg + 2 kg + 3 kg =

6 kg. Applying Newton's second law ($a = F/m$), the system's acceleration is 18 N divided by 6 kg, which equals 3 m/s². Internal string tensions cancel out.

63. Identify the singular distinct real-life situation that fundamentally does NOT primarily illustrate a direct protective safety application of Newton's second law of stopping motion:
- Fielders deliberately pulling hands firmly backward while catching heavily
 - Modern vehicles deploying soft airbags violently upon crashing
 - Swimmers forcefully pushing dense pool water vigorously backward
 - Athletes falling safely onto thick spongy landing mats

Ans : (C)

Fielders pulling hands, modern airbags inflating, and athletes falling on soft thick mats are all excellent applications deliberately extending stopping time to precisely reduce severe impact force strictly under the second law. Conversely, a swimmer vigorously pushing thick water heavily backward fundamentally relies entirely upon strict action-reaction opposing pairs explicitly defined by the third law.

64. Complete the fundamental scientific analogy below correctly based upon the standard international metric units extensively discussed precisely in this chapter: Force is properly related strictly to Newton as Mass is properly related strictly to:
- Pascal
 - Kilogram
 - Metre
 - Second

Ans : (B)

In the globally accepted International System of Units widely utilised throughout physics, the strict standard measuring unit accurately defining external applied force is the newton. Following this identical precise scientific pattern, the exact strict standard metric unit specifically utilised for accurately measuring an object's fundamental physical internal mass is the standard kilogram.

65. If careful mathematical calculation strongly determines that the total physical acceleration of a sliding block is strictly absolutely zero, which specific physical conclusion is undeniably entirely true?

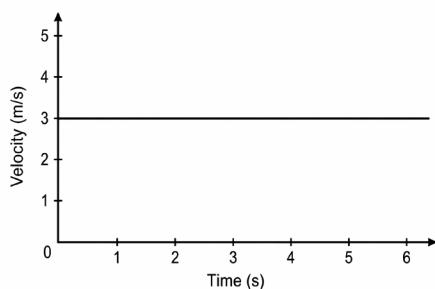
inversely proportional to mass. The lighter astronaut accelerates at two meters per second squared, while the heavier satellite accelerates at only zero point four.

48. A 5 kg block is rapidly sliding on a heavily textured rough floor. The maximum force of friction opposing it is 15 N. If no forward pushing force is applied, calculate the magnitude of its deceleration.
- (A) 0.33 ms^{-2}
 (B) 3 ms^{-2}
 (C) 10 ms^{-2}
 (D) 75 ms^{-2}

Ans : (B)

Without any active forward applied force, the sole horizontal net force acting upon the block is the fifteen newtons of opposing friction. Utilising the formula $a = F/m$, we divide this fifteen newton backward force by the total five kilogram mass. This strict calculation precisely yields a steady deceleration of exactly three metres per second squared.

49. A worker continuously pushes a heavy crate across a horizontal concrete floor. The resulting motion of the crate is plotted on the provided graph. What can be concluded about the horizontal forces acting on the crate during this time?



- (A) The applied force provided by the worker is continuously increasing.
 (B) The applied force is strictly greater than the opposing frictional force.
 (C) The net horizontal force is zero because applied force balances friction.
 (D) The frictional force is completely absent due to the constant motion.

Ans : (C)

The horizontal straight line on the velocity-time graph demonstrates that the crate moves with a constant velocity, meaning acceleration is zero. According to Newton's first law, zero acceleration

requires a zero net force. Therefore, the applied force perfectly balances the opposing frictional force. The incorrect options assume a net force or ignore friction entirely.

50. A 1000 kg automobile uniformly accelerates strictly from rest to a steady velocity of 20 ms^{-1} in exactly 5 seconds. What is the magnitude of the constant net force acting upon the accelerating car?
- (A) 4000 N
 (B) 2000 N
 (C) 10000 N
 (D) 500 N

Ans : (A)

Initially, we must determine the exact acceleration using the kinematic equation $a = (v - u)/t$. Subtracting zero from twenty and dividing by five seconds precisely yields an acceleration of four metres per second squared. Multiplying this calculated acceleration by the car's massive one thousand kilogram mass accurately gives a total force of four thousand newtons.

51. Two heavy structural blocks of mass m_1 and m_2 are tied tightly together by a string and pulled vigorously by a massive single force F . What is the common acceleration of this unified system?
- (A) F/m_1
 (B) F/m_2
 (C) $F/(m_1 - m_2)$
 (D) $F/(m_1 + m_2)$

Ans : (D)

When strongly connected objects are deliberately treated analytically as a single unified system, their individual masses are added together to form a total systemic mass. Using Newton's second law for the entire connected system, the common external acceleration is mathematically found precisely by dividing the total external pulling force by the combined total mass ($m_1 + m_2$).

52. A small spherical ball is moving uniformly on a perfectly smooth, completely frictionless horizontal surface. If absolutely no external net force is continuously applied, the internal velocity of the rolling ball will:
- (A) Gradually increase exponentially over time
 (B) Suddenly decrease quickly to zero
 (C) Steadily remain exactly the same
 (D) Frequently fluctuate unpredictably over distance

77. What is the relationship between the net force acting on a body and its acceleration according to the first law?

Ans :

If the net force acting on an object is strictly zero, the body cannot change its velocity, meaning its resulting acceleration is exactly zero.

78. What would happen to the position-time graph of an object moving with constant velocity?

Ans :

When an object is moving with a constant velocity and zero net force, its position-time graph will always be represented as a straight line.

79. Write the mathematical expression for Newton's second law of motion.

Ans :

Newton's second law of motion is mathematically expressed by the equation $F = ma$, where F is force, m is mass, and a is acceleration.

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80. What is the scientific term for the product of an object's mass and its velocity?

Ans :

The product of an object's mass and its velocity is known as its momentum, which helps explain Newton's second law in more comprehensive terms.

81. How does pulling hands backward while catching a fast cricket ball help the fielder?

Ans :

Pulling hands backward increases the time duration for stopping the ball, reducing its acceleration and thereby minimizing the required stopping force and potential injury.

82. Give one real-life application where extending collision time is used for safety in vehicles.

Ans :

Airbags in vehicles quickly inflate during a collision to cushion the passenger, increasing the stopping time and greatly reducing the force exerted on them.

83. Define one newton of force based on Newton's second law.

Ans :

One newton is defined as the exact amount of force that produces an acceleration of one meter per second squared on a one-kilogram mass.

84. What is the approximate value of acceleration due to gravitational force by the Earth near its surface?

Ans :

The acceleration due to Earth's gravitational force is denoted by g , and its fairly constant value near the surface is 9.8 meters per second squared.

85. State Newton's third law of motion.

Ans :

Whenever one object exerts a force on a second object, the second object simultaneously exerts an equal and completely opposite force on the first object.

86. State one major difference between the action and reaction forces described in Newton's third law.

Ans :

Although action and reaction forces are always equal in magnitude and opposite in direction, they specifically act on two completely different interacting objects simultaneously.

87. Why do we sometimes struggle to walk on wet polished floors or ice?

Ans :

We struggle to walk on these surfaces because the drastically reduced force of friction makes it difficult to push the ground backward effectively without slipping.

88. Give one reason why a fired bullet and the recoiling gun do not have the same acceleration despite equal forces.

Ans :

Although the interacting forces are strictly equal in magnitude, the resulting accelerations differ significantly because the gun's mass is much larger than the bullet's mass.

- 89.** How does a rocket utilize Newton's third law to launch into space?

Ans :

The rocket engine forcefully expels exhaust gases downwards, simultaneously exerting an equal and opposite upward reaction force on the rocket, allowing it to lift off.

- 90.** Give one example of Newton's third law in daily life involving water.

Ans :

When a canoeist forcefully pushes water backwards with a paddle, the water simultaneously pushes the paddle and canoe forward with an equal and opposite force.

- 91.** What is meant by treating connected boxes as a "single system" in physics?

Ans :

Treating connected boxes as a single system means analyzing their combined motion together, requiring consideration of only external forces while completely ignoring their internal forces.

- 92.** State one similarity in how Newton's second law applies to a single object versus a system of connected objects.

Ans :

In both scenarios, the total resulting acceleration of the entity is directly proportional to the net external force and inversely proportional to the total mass.

- 93.** What is the significance of distinguishing between internal and external forces in a multiobject system?

Ans :

Distinguishing them greatly simplifies scientific analysis because internal forces simply balance each other out, meaning only the external forces dictate the entire system's overall acceleration.

- 94.** Under what condition does an object floating on water remain perfectly stationary?

Ans :

An object floating on water remains stationary when the downward gravitational force is perfectly balanced by the equal and opposite upward buoyant force of water.

- 95.** What is the relationship between the applied force and acceleration for an object of fixed mass?

Ans :

For an object of fixed mass, the acceleration produced is directly proportional to the net force applied to it, acting in the same exact direction.

SHORT ANSWER QUESTIONS

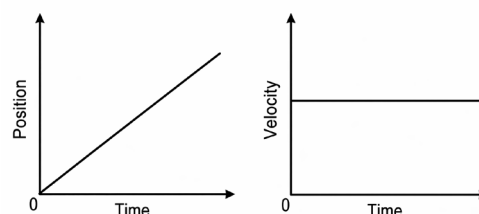
- 96.** Explain the concept of balanced forces with the help of an example. What happens to the state of motion of an object when balanced forces act on it?

Ans :

Balanced forces occur when multiple forces acting on an object are equal in magnitude but opposite in direction. In this situation, the forces effectively cancel each other out, resulting in a net force of exactly zero. Because the net force is zero, balanced forces do not change the state of rest or the state of uniform motion of the object. For example, in a tug-of-war, if both teams pull the rope with equal force from opposite sides, the rope remains completely stationary.

- 97.** Draw the position-time and velocity-time graphs for an object moving with a constant velocity. What does this indicate about the net force acting on the object?

Ans :



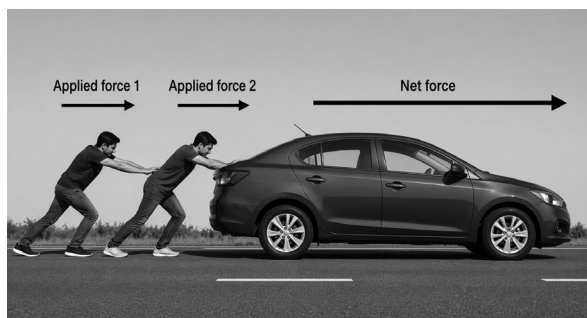
When an object moves with a constant velocity, its speed and direction do not change. According to Newton's first law of motion, an object maintains a constant velocity only when the net external force acting on it is exactly zero. The position-time graph is a straight sloping line, and the velocity-time graph is a flat horizontal line, both visually confirming that no unbalanced force is causing acceleration or deceleration to the object.

98. What is the SI unit of force? How can you use a simple spring balance to measure the magnitude of a force?

Ans :

The SI unit of force is the newton, represented by the symbol N. A spring balance contains a coiled spring inside it that stretches when a force is applied. To measure the magnitude of a pulling force, you simply attach the object or apply the pull to the free hook at the end of the spring balance. The spring stretches in proportion to the applied force, and the reading indicated on the calibrated scale provides an approximate measure of the force's magnitude.

99. Study the scenario shown in the diagram.



How do you calculate the magnitude and direction of the net force in this scenario? How would this change if they pushed the car from opposite ends?

Ans :

In this scenario, since both people are applying forces on the stalled car in the exact same direction, the magnitude of the net force is calculated by simply adding the magnitudes of their individual forces together. The direction of this net force will be in the same forward direction. If they were to push the car from opposite ends, the forces would oppose each other. The net force would then be the difference between their magnitudes, acting in the direction of the larger applied force.

100. State Newton's second law of motion. How does this mathematical relationship help us formally define one newton of force?

Ans :

Newton's second law of motion states that when a net force acts on an object, it accelerates in the direction of the net force. The magnitude of acceleration is directly proportional to the net force and inversely proportional to the mass.

Mathematically, it is expressed as force equals mass times acceleration. Using this law, one newton of force is formally defined as the exact amount of force required to produce an acceleration of one meter per second squared on an object having a mass of one kilogram.

101. State Newton's first law of motion. Explain how this law contradicts the ancient misconception regarding moving objects.

Ans :

Newton's first law of motion states that an object at rest remains at rest, and an object in motion continues to move with a constant velocity, unless a net external force acts upon it. For centuries, people mistakenly believed that a continuous applied force was absolutely necessary to keep an object moving at a steady speed. Galileo and Newton corrected this by showing that in the absence of opposing forces like friction, a moving object will continue its motion indefinitely without any additional force.

102. A student claims that a heavy box pushed across a room requires a constant continuous force just to keep it moving at a constant velocity, which proves Newton's first law wrong. Do you agree? Justify.

Ans :

I disagree with the student's conclusion. The situation does not prove Newton's first law wrong; rather, it involves the presence of friction. When moving a heavy box, the floor exerts a frictional force in the direction opposite to the motion. To keep the box moving at a constant velocity, you must apply a continuous forward force that exactly equals the opposing frictional force. This balances the forces, making the net force zero, which perfectly aligns with Newton's first law of motion.

103. What is inertia? Which famous scientist introduced this term to describe the inherent tendency of objects regarding motion?

Ans :

Inertia is the inherent physical property or tendency of objects to resist any change in their current state of rest or state of uniform motion. If an object is resting, it tends to stay resting; if it is moving, it tends to keep moving steadily. The famous scientist Isaac Newton used this specific

By third equation of motion

$$v^2 - u^2 = 2as$$

$$(0 \text{ ms}^{-1})^2 - (20 \text{ ms}^{-1})^2 = 2 \times a \times 50 \text{ m}$$

$$-400 \text{ m}^2\text{s}^{-2} = 100 \text{ m} \times a$$

$$a = -\frac{400 \text{ m}^2\text{s}^{-2}}{100 \text{ m}}$$

$$a = -4 \text{ ms}^{-2}$$

By Newton's second law of motion :

$$F = m \times a$$

$$= 1 \text{ kg} \times (-4 \text{ ms}^{-2})$$

$$= -4 \text{ N}$$

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- 137.** A 8000 kg engine pulls a train of 5 wagons, each of 2000 kg, along a horizontal track. If the engine exerts a force of 40000 N and the track offers a friction force of 5000 N, then calculate :

- the net accelerating force,
- the acceleration of the train, and
- the force of wagon 1 on wagon 2.

Ans :

Given, Mass of engine $m_1 = 8000 \text{ kg}$

Mass of each wagon $m_2 = 2000 \text{ kg}$

Number of wagons $n = 5$

$$\begin{aligned} \text{Total mass of 5 wagons} &= 2000 \text{ kg} \times 5 \\ &= 10000 \text{ kg} \end{aligned}$$

Force exerted by engine, $F_1 = 40,000 \text{ N}$

Frictional force offered by the track,

$$F_2 = 5000 \text{ N}$$

- Net accelerating force,

$$\begin{aligned} F &= F_1 - F_2 \\ &= (40,000 - 5,000) \text{ N} \\ &= 35,000 \text{ N} \end{aligned}$$

- Acceleration of the train,

$$\begin{aligned} a &= \frac{F}{m} \\ a &= \frac{35000 \text{ N}}{10000 \text{ kg}} = 3.5 \text{ ms}^{-2} \end{aligned}$$

- Force of wagon 1 on wagon 2

$$\begin{aligned} &= (35,000 - 35,000/5) \text{ N} \\ &= (35,000 - 7000) \text{ N} \\ &= 28,000 \text{ N} \end{aligned}$$

- 138.** An automobile vehicle has a mass of 1500 kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of 1.7 ms^{-2} ?

Ans :

Given,

Mass of vehicle $m = 1500 \text{ kg}$

Acceleration $a = -1.7 \text{ ms}^{-2}$

By second law of motion :

$$\begin{aligned} F &= m \times a \\ &= 1500 \times -1.7 \\ &= -2550 \text{ N} \end{aligned}$$

Negative sign shows that the force is in a direction opposite to the direction of motion of the vehicle

- 139.** A hockey ball of mass 200 g travelling at 10 ms^{-1} is struck by a hockey stick so as to return it along its original path with a velocity at 5 ms^{-1} . Calculate the change of momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.

Ans :

Given,

Mass of hockey ball $m = 200 \text{ g}$

$$= \frac{200}{1000} = 0.2 \text{ kg}$$

Initial velocity of the ball $u = 10 \text{ ms}^{-1}$

Final velocity of the ball $v = -5 \text{ ms}^{-1}$ (Hockey ball travels in opposite direction)

Initial momentum of the ball $= m \times u$

$$\begin{aligned} &= 0.2 \text{ kg} \times 10 \text{ ms}^{-1} \\ &= 2 \text{ kg ms}^{-1} \end{aligned}$$

Final momentum of the ball $= m \times v$

$$\begin{aligned} &= 0.2 \text{ kg} \times (-5 \text{ ms}^{-1}) \\ &= -1 \text{ kg ms}^{-1} \end{aligned}$$

Change of momentum $= mv - mu$

$$\begin{aligned} &= (-1 - 2) \text{ kg ms}^{-1} \\ &= -3 \text{ kg ms}^{-1} \end{aligned}$$

- 140.** A bullet of mass 10 g travelling horizontally with a velocity of 150 ms^{-1} strikes a stationary wooden block and comes to rest in 0.03 s. Calculate the distance of penetration of the bullet into the block. Also calculate the magnitude of the force exerted by the wooden block on the bullet.

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- 109.** Compare balanced and unbalanced forces with respect to their magnitude, direction, and their ultimate effect on the state of motion of an object.

Ans :

Balanced forces are two or more forces acting on an object that are exactly equal in magnitude but strictly opposite in direction. Because they cancel each other completely, their net force is zero, meaning they do not change the object's state of rest or constant velocity. In contrast, unbalanced forces are unequal in magnitude or do not act in perfectly opposite directions. They produce a non-zero net force, which inevitably causes the object to accelerate, change its speed, or alter its direction.

- 110.** Study the given diagram of a weightlifter.



Ans :

The Earth exerts a downward gravitational force on the barbell, which is calculated by multiplying its mass by the acceleration due to gravity. For a 30 kg mass, this force is $30 \text{ kg} \times 9.8 \text{ m/s}^2$, equalling 294 N downwards. To keep the barbell perfectly steady, the weightlifter must apply an upward force that exactly balances this weight. Therefore, she applies a force of 294 N upwards. Because these opposing forces are balanced, the total net force acting on the barbell is zero.

- 111.** A bullet of mass 0.1 kg is fired horizontally from a 5 kg gun. If the force acting on the bullet is 2 N, calculate the initial accelerations of both the bullet and the gun.

Ans :

Given:

Mass of bullet, $m_1 = 0.1 \text{ kg}$

Mass of gun, $m_2 = 5 \text{ kg}$

Force acting on the bullet, $F = 2 \text{ N}$

By Newton's Second Law of Motion: $a = F/m$

Acceleration of the bullet:

$$a_{\text{bullet}} = \frac{F}{m_1} = \frac{2}{0.1} = 20 \text{ m/s}^2 \quad (\text{forward})$$

By Newton's Third Law of Motion, the bullet exerts an equal and opposite reaction force of 2 N on the gun in the backward direction.

Acceleration of the gun:

$$a_{\text{gun}} = \frac{F}{m_2} = \frac{2}{5} = 0.4 \text{ m/s}^2 \quad (\text{backward})$$

According to Newton's third law of motion, the force propelling the bullet forward and the recoil force pushing the gun backward are equal and opposite, both measuring 2 N. Using Newton's second law, acceleration equals force divided by mass. The gun's initial acceleration is calculated as 2 N divided by 5 kg, yielding 0.4 m/s^2 . The bullet's initial acceleration is 2 N divided by 0.1 kg, which results in a significantly much higher acceleration of 20 m/s^2 due to its tiny mass.

- 112.** What is the essential function of airbags in modern vehicles? How do they prevent serious injuries during a sudden collision?

Ans :

Airbags are designed to act as soft, compressible cushions that rapidly inflate inside a vehicle during a severe collision. Without an airbag, a passenger would hit the hard dashboard, stopping almost instantly. The airbag significantly increases the time duration over which the passenger's forward velocity is reduced to zero. According to Newton's second law of motion, increasing this stopping time drastically reduces the deceleration, which in turn reduces the magnitude of the force exerted on the person's body, preventing serious trauma.

- 113.** A student pushes a stationary 25 kg block on a horizontal floor. The maximum force of friction opposing the motion is 50 N. Calculate the acceleration of the block if the student applies a constant force of 55 N forward.

Ans :

When the student pushes the block with a forward force of 55 N, the rough floor exerts a maximum opposing frictional force of 50 N backward. The net force acting on the block is the difference between these two opposing forces, which is 55 N minus 50 N, giving a net forward force of 5 N. According to Newton's second law, acceleration is

- (b) This fundamental principle perfectly explains the mechanics of human walking. When you attempt to walk forward, your foot actively pushes against the ground in the backward direction. In immediate response, the ground applies an equal and opposite reaction force on your foot in the forward direction. It is this forward frictional force from the ground that actually propels your body ahead.
- (c) Although the action and reaction forces are completely equal in magnitude and strictly opposite in direction, they do not cancel each other out because they act on entirely different objects. One force forcefully acts on the ground while the opposite reaction force acts on your body, allowing net movement to successfully occur.

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131. (a) According to gravitational principles, the Earth and a falling apple exert equal and opposite forces on each other. Why does the apple fall towards the Earth, but the Earth does not visibly move towards the apple?
- (b) A 0.05 kg bullet is fired from a 4 kg gun with a force of 10 N; calculate the initial acceleration of both the bullet and the gun?

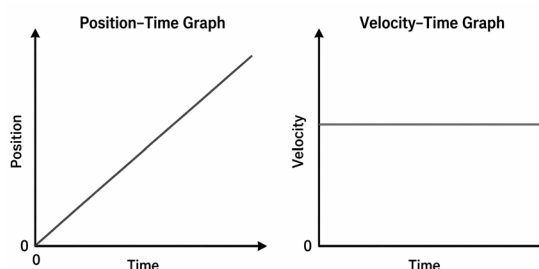
Ans :

- (a) According to Newton's third law, the Earth and a falling apple exert equal and opposite gravitational forces on each other. However, Newton's second law dictates that acceleration is inversely proportional to mass. The mass of the Earth is astronomically larger compared to the tiny mass of the apple. Consequently, the same magnitude of force produces a significant, observable acceleration in the light apple, causing it to fall rapidly, but an infinitesimally small, unnoticeable acceleration in the massive Earth.
- (b) For the numerical portion, we use the formula acceleration equals force divided by mass. The initial acceleration of the bullet is calculated by dividing the ten newton force by its mass of zero point zero five kilograms, resulting in two hundred metres per second squared. The gun's recoil acceleration is ten newtons divided by its four kilogram mass, yielding exactly two point five metres per second squared.

132. (a) Draw the position-time and velocity-time graphs for an object moving along a straight line with a constant velocity?
- (b) Based on Newton's first law, what is the net force acting on this object?
- (c) Explain why a moving object eventually comes to rest in the real world if no continuous forward push is applied?

Ans :

(a)



- (b) Based on Newton's first law of motion, an object moving with a constant velocity has a strictly zero net force acting upon it. Because there is absolutely no change in either the speed or the direction of the object, its acceleration is zero, which mathematically confirms the complete absence of a net external force. In a theoretical frictionless environment, such an object would continue moving indefinitely.
- (c) However, in the real world, an object moving across a surface eventually comes to rest because forces are rarely completely absent. Even if no human pushes it, the unseen force of friction between the interacting surfaces, alongside air resistance, continuously acts in the direction directly opposite to the object's motion. This unbalanced opposing force creates negative acceleration, gradually slowing the object down until it finally stops moving completely.
133. (a) Using the relationships established in Newton's second law, how does the acceleration of an object change when the applied net force is exactly doubled while its mass remains constant?
- (b) How does the acceleration change if the mass is doubled while the force remains constant?
- (c) Calculate the specific force required to impart an acceleration of 2.5 m/s^2 to a block of mass 10 kg?

attached to it—forward with an equal reactive force, enabling the canoe to accelerate smoothly across the lake.

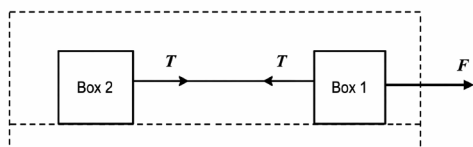
- 119.** Why is it notoriously difficult to walk safely on wet polished floors or smoothly frozen ice? Explain using the concept of interacting forces.

Ans :

Walking fundamentally relies on the friction between your footwear and the ground surface. When you walk, your foot pushes backward against the ground, and by Newton's third law, the frictional force from the ground pushes you forward. Wet polished floors or smooth ice have remarkably low levels of surface friction. Without sufficient grip, your foot slips backward when trying to push, and the ground cannot provide an adequate forward reaction force, making it extremely difficult to propel yourself safely forward.

- 120.** Draw a block diagram showing a system of two boxes connected by a string being pulled to the right. Why is the tension force in the connecting string considered an internal force when analysing the whole system?

Ans :



When treating both boxes and the string collectively as a single unified system, the tension forces exist entirely inside the boundaries of this chosen system. According to Newton's third law, Box 1 pulls Box 2 rightward with tension T , and Box 2 pulls Box 1 leftward with an equal tension T . Because these action-reaction pairs act strictly within the system's boundary, they perfectly cancel each other out when calculating the overall net force, thus making them internal forces.

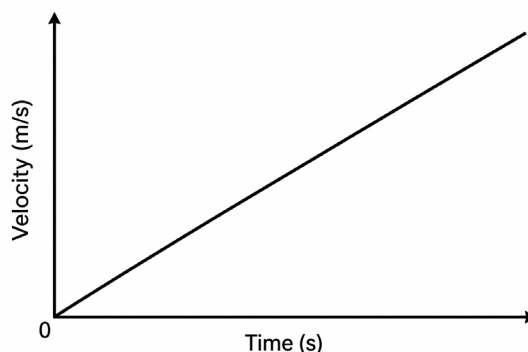
- 121.** What are the two vertical forces acting on a plastic ball floating motionless on the surface of a pond? Why does the ball remain completely at rest vertically?

Ans :

When a plastic ball is floating motionless on water, it is subjected to two distinct vertical forces. The first is the gravitational force exerted by the Earth, which pulls the ball downwards. The second is the buoyant force exerted by the liquid water, which pushes the ball upwards. The ball remains completely at rest in the vertical direction because these two forces are perfectly equal in magnitude and directly opposite in direction, creating balanced forces and a net vertical force of zero.

- 122.** Draw a velocity-time graph for a car starting from rest and moving with uniform acceleration. How can you use this graph alongside Newton's laws to find the net force acting on the car?

Ans :



The velocity-time graph for a uniformly accelerating car is a straight line inclined to the time axis. To find the net force acting on the car, you first calculate the physical slope of this straight line. The value of this slope directly gives the constant acceleration of the car. Once the acceleration is determined, you multiply it by the known mass of the car using Newton's second law equation ($F = ma$) to calculate the exact net force acting upon it.

- 123.** When dealing with two attached objects like a cart towing a trailer, why do physicists often treat them as a single combined system? How does this mathematically simplify finding the acceleration?

Ans :

Physicists often treat connected objects as a single combined system to greatly simplify motion analysis. When viewed as one system, the complex internal forces acting between the individual objects—such as the tension in the towing rope—cancel each other out completely in pairs. This

word and concept to frame his first law of motion in 1687, building upon earlier revolutionary thought experiments conducted by Galileo Galilei in the seventeenth century regarding frictionless movement.

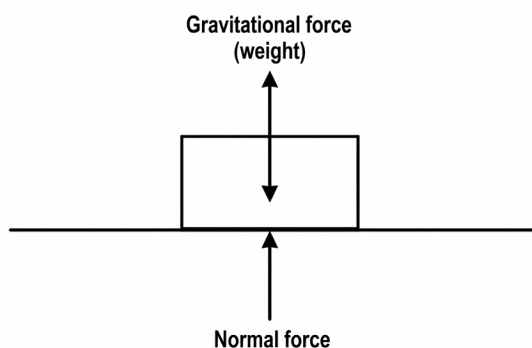
104. When you try to push a heavy box resting on the floor with a small force, it does not move. Explain the scientific reason behind this observation.

Ans :

When you apply a small force to a stationary heavy box, it does not move because an opposing force called friction arises between the bottom surface of the box and the floor. This frictional force acts in the exact opposite direction to your applied push. As long as your applied force is smaller than or equal to the maximum opposing friction, the two forces balance each other out perfectly. Since the net force remains zero, the box does not accelerate and stays at rest.

105. Draw a diagram of a block placed at rest on a horizontal table, showing the vertical forces acting on it. Why does the block not move vertically despite these forces?

Ans :



The block experiences a downward gravitational force exerted by the Earth and an upward normal force exerted by the surface of the table. The block does not move in the vertical direction because these two specific forces are exactly equal in magnitude and strictly opposite in direction. They completely cancel each other out, resulting in a net vertical force of zero. According to Newton's first law, with zero net force, the block remains stationary vertically.

106. How is the acceleration of an object mathematically related to its applied force? What happens to the acceleration if the object's mass is doubled while the applied force remains constant?

Ans :

According to Newton's second law of motion, the acceleration of an object is directly proportional to the net applied force and inversely proportional to the object's mass. This means that a larger net force produces a proportionally larger acceleration. However, because acceleration is inversely related to mass, if you double the mass of the object while keeping the applied force exactly the same, the acceleration will decrease by half. Heavier objects require much more force to achieve the same acceleration as lighter ones.

107. Explain the physics behind why a cricketer gradually pulls their hands backward while catching a fast-moving ball.

Ans :

When catching a fast-moving cricket ball, the fielder gradually pulls their hands backward to intentionally increase the time duration over which the ball's high velocity is reduced to zero. According to Newton's second law of motion, an increase in the time taken to stop the ball significantly reduces the magnitude of the deceleration. Consequently, a much smaller opposing force is required to bring the ball to rest, which safely minimizes the impact force on the fielder's hands and prevents serious injuries.

108. When an apple falls towards the Earth, Newton's third law states the Earth also experiences an equal upward force. Why is the Earth's acceleration towards the apple not noticeable?

Ans :

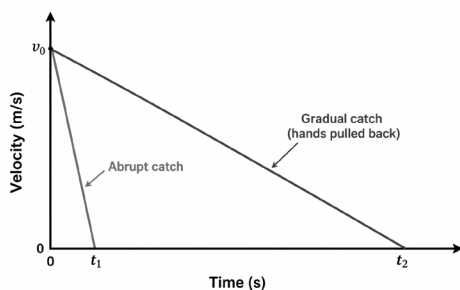
It is true that the apple and the Earth exert equal and opposite gravitational forces on each other. However, according to Newton's second law of motion, the acceleration produced by a force is inversely proportional to the mass of the object. While the apple has a tiny mass and accelerates at 9.8 m/s^2 , the Earth has an incredibly massive size. When this same small force is divided by the gigantic mass of the Earth, the resulting acceleration is infinitesimally small and impossible to notice.

- (b) To demonstrate that friction depends on the nature of the surfaces, place a wooden block on a normal table and pull it with a horizontally attached spring balance until it just starts moving. Note the reading, which indicates the force of friction. Repeat this experiment by placing the same block on different surfaces like polished marble or a laminated top. The varying spring balance readings will clearly indicate that rougher surfaces offer significantly greater friction than smoother ones.
- (c) Although Newton's first law states objects move uniformly without external forces, we must continuously apply a pedal force to keep a bicycle moving to perfectly counter this ever-present friction and maintain a zero net force.

- 128.** (a) Draw a velocity-time graph showing the motion of a fast cricket ball being caught in two scenarios: an abrupt catch and a gradual catch where the fielder pulls their hands backwards?
- (b) Explain the scientific principle behind pulling the hands back using Newton's second law?
- (c) How do vehicle airbags use this same principle during collisions?

Ans :

- (a)



- (b) According to Newton's second law of motion, the acceleration of an object is inversely proportional to the time taken for a change in velocity. When a cricketer catches a fast-moving ball and pulls their hands backwards, they strategically increase the time duration over which the high velocity of the ball reduces to zero. This extended time significantly decreases the deceleration of the ball. Consequently, a much smaller net force is required to stop the ball, thereby minimising

the impact and preventing serious injury to the fielder's hands.

- (c) This identical scientific principle is applied in vehicle air-bags. During an abrupt collision, an air-bag inflates to provide a soft compressible cushion. It delays the passenger's forward motion, increasing the time over which their velocity reaches zero. This critically reduces the acceleration and lowers the exerted force, substantially reducing the risk of fatal injuries.

- 129.** (a) State Newton's second law of motion and express it mathematically?
- (b) A sports car of mass 1200 kg accelerates uniformly from rest to a velocity of 20 m/s in 4 seconds. Calculate the acceleration of the car and the net force acting on it?

Ans :

- (a) Newton's second law of motion states that when a net force acts on an object, it accelerates in the direction of the net force, where the magnitude of acceleration is proportional to the net force and inversely proportional to the object's mass. Mathematically, it is expressed as $a = F/m$, which is commonly rearranged as $F = ma$, where F is the net force, m is the mass, and a is the acceleration.
- (b) For the sports car, the initial velocity is zero, and the final velocity is twenty metres per second over a time interval of four seconds. Using the kinematic equation, acceleration is the change in velocity divided by time, yielding five metres per second squared. Using the second law equation, the net force is the mass of twelve hundred kilograms multiplied by the acceleration of five, giving a net force of six thousand newtons.

- 130.** (a) State Newton's third law of motion?
- (b) Explain in detail how this law enables a person to walk naturally on the ground?
- (c) If the action and reaction forces are always equal and opposite, why do they not simply cancel each other out when we walk?

Ans :

- (a) Newton's third law of motion states that whenever one object exerts a force on a second object, the second object is simultaneously exerting an equal and opposite force on the first object.

allows us to use Newton's second law by simply dividing the total external pulling force by the combined total mass of both objects, effortlessly yielding the system's overall acceleration without needing to solve multiple simultaneous equations.

- 124.** Have you ever noticed people cracking a fresh hard coconut in one go by hitting it forcefully on the ground? Explain the science behind how the shell breaks using Newton's laws.

Ans :

Breaking a hard coconut in one go is a practical application of Newton's second law of motion. When the fast-moving coconut violently hits the hard, unyielding ground, its velocity is abruptly reduced to absolute zero in a fraction of a second. Because the time duration of this impact is extremely short, the resulting deceleration is massively high. Consequently, the ground exerts an enormous reaction force back on the coconut shell, which surpasses its structural strength, causing it to instantly crack open.

- 125.** Imagine a hypothetical scenario where the force of friction completely disappears from the entire world. Describe two immediate severe consequences this would have on everyday human movement or transportation.

Ans :

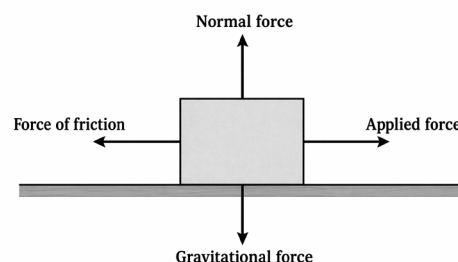
If friction were to completely vanish from the world, the consequences would be catastrophic for daily activities. First, humans would be entirely unable to walk or run; without friction to provide a forward reaction force against our footsteps, we would simply slip uncontrollably in place. Second, wheeled vehicles like cars and bicycles could neither steer, accelerate, nor apply brakes safely. Any moving object on a flat path would simply glide forever at a constant speed, unable to deliberately stop or change direction.

LONG ANSWER QUESTIONS

- 126.** (a) Draw a diagram showing the horizontal and vertical forces acting on a wooden block being pushed across a table but remaining completely stationary?
 (b) Identify the balanced force pairs?
 (c) Explain how Newton's first law of motion applies to this specific situation?

Ans :

(a)



- (b) When a wooden block is pushed but remains stationary, multiple forces act upon it, but they form balanced pairs. The downward gravitational force exerted by the Earth is perfectly balanced by the upward normal force exerted by the table's surface. Similarly, the applied horizontal push is completely balanced by an equal and opposite force of friction acting between the bottom of the block and the table. Since the opposing forces cancel each other out, the net force acting on the block is zero.
- (c) According to Newton's first law of motion, an object at rest will remain at rest unless acted upon by a non-zero net force. Because the forces are balanced, the state of the block does not change, and it continues to remain completely stationary on the table without experiencing any acceleration.

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- 127.** (a) What is the force of friction and what generally causes it?
 (b) Describe briefly how you would use a spring balance and a wooden block to show that friction depends on the nature of the surfaces in contact?
 (c) Why do we need to continuously apply a forward force to keep a bicycle moving at a constant velocity?

Ans :

- (a) The force of friction is a resistive force that opposes the relative motion between two surfaces in contact. It arises due to the interactions and interlocking between the surfaces at the microscopic level.

Ans :

- (a) According to Newton's second law of motion, the acceleration of an object is directly proportional to the net force acting upon it and inversely proportional to its mass. Therefore, if the applied net force is intentionally doubled while the mass is kept entirely constant, the resulting acceleration of the object will also be exactly doubled.
- (b) Conversely, if the mass of the object is doubled while applying the exact same constant force, the object inherently becomes heavier and much harder to move, causing the resulting acceleration to be strictly reduced to exactly half of its original value.
- (c) To calculate the urgently required force for the specific block, we apply the foundational mathematical equation Force equals mass multiplied by acceleration. By multiplying the block's given mass of ten kilograms by the desired acceleration of two point five metres per second squared, we conclusively determine that a net force of twenty-five newtons is required.

- 134.** (a) Describe the general mechanism of a rocket launch into space using the principles of Newton's third law of motion?
- (b) How did the Vikram lander of Chandrayaan-3 use this exact same physical principle to intentionally slow down and achieve a successful soft landing near the Moon's south pole?

Ans :

- (a) A rocket launch is a classic and powerful demonstration of Newton's third law of motion, which states that every action has an equal and opposite reaction acting on different bodies. During a launch, the rocket engine rapidly burns fuel to produce continuously expanding exhaust gases. The engine forcefully expels these highly pressurised gases downwards towards the ground. This deliberate downward push constitutes the action force. Simultaneously, the expelled exhaust gases exert an exactly equal and opposite reaction force upwards on the rocket itself. Because this upward thrust is significantly larger than the gravitational weight of the rocket, it smoothly accelerates upwards into space.

- (b) The Vikram lander ingeniously utilised this exact principle but in reverse for its lunar descent. By actively firing its thrusters in the downward direction of its motion, the expelled gases created a strong opposing upward reaction force. This counter-force deliberately reduced the lander's velocity, enabling a completely safe soft landing.

NUMERICAL QUESTIONS

- 135.** A truck starts from rest and rolls down a hill with a constant acceleration. It travels a distance of 400 m in 20 s. Find its acceleration. Find the force acting on it if its mass is 7 tonnes (Hint : 1 tone = 1000 kg).

Ans :

Given,

Initial velocity, $u = 0 \text{ ms}^{-1}$

Distance $s = 400 \text{ m}$

Time $t = 20 \text{ s}$

Mass $m = 7 \text{ metric tons} = 7000 \text{ kg}$

By second equation of motion,

$$s = ut + \frac{1}{2} at^2$$

$$400 = 0 \text{ ms}^{-1} \times 20 \text{ s} + \frac{1}{2} \times a \times (20 \text{ s})^2$$

$$400 = \frac{1}{2} \times a \times 400 \text{ s}^2$$

$$a = \frac{800 \text{ m}}{400 \text{ s}^2} = 2 \text{ ms}^{-2}$$

By Newton's second law of motion :

$$F = m \times a$$

$$= 7000 \text{ kg} \times 2 \text{ ms}^{-2} = 14000 \text{ N}$$

- 136.** A stone of 1 kg is thrown with a velocity of 20 ms^{-1} across the frozen surface of a lake and comes to rest after travelling a distance of 50 m. What is the force of friction between the stone and the ice?

Ans :

Given,

Mass $m = 1 \text{ kg}$

Initial velocity $u = 20 \text{ ms}^{-1}$

Final velocity $v = 0 \text{ ms}^{-1}$

Distance $s = 50 \text{ m}$

net force divided by mass. Dividing the 5 N net force by the 25 kg mass gives an acceleration of 0.2 m/s^2 .

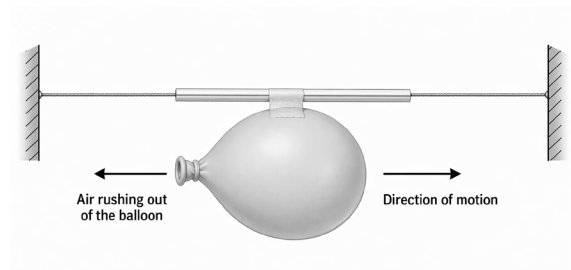
114. Renu argues that since action and reaction forces are always exactly equal and opposite, they should cancel each other out, meaning no object should ever be able to accelerate. Do you agree? Justify.

Ans :

I strongly disagree with Renu's reasoning. While Newton's third law states that action and reaction forces are indeed equal in magnitude and opposite in direction, the crucial detail is that they always act on two distinctly different objects. Forces can only cancel each other out if they are acting on the exact same object. Because the action acts on one body and the reaction acts on the other interacting body, they do not balance each other, and both objects can independently accelerate.

115. Draw a labelled diagram showing a balloon sliding along a stretched thread. Explain the forces causing the balloon's motion based on Newton's laws.

Ans :



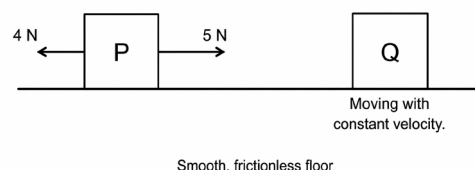
When the neck of the inflated balloon is released, the stretched rubber forcefully expels the trapped air molecules out in the backward direction. According to Newton's third law of motion, this action causes an equal and opposite reaction force. The expelled air pushes back on the balloon material with the same magnitude of force in the forward direction. Since this forward reaction force is unbalanced, it provides acceleration, causing the balloon to swiftly move forward along the guiding thread.

116. Compare the resulting acceleration of a highly massive truck and a small light car if both are pushed on a smooth road with the identical net force. Which law of motion primarily explains this relationship?

Ans :

If an identical net force is applied to a massive truck and a light car, the light car will experience a significantly larger acceleration compared to the heavy truck. This inverse relationship is entirely explained by Newton's second law of motion, which explicitly states that the acceleration produced by a net force is inversely proportional to the mass of the object. Since the truck has much greater mass, it possesses more inertia and stubbornly resists changes to its motion, resulting in smaller acceleration.

117. Study the diagram showing two blocks on a smooth surface.



Which block is currently experiencing a net force? Describe the expected state of motion for both blocks based on the given forces.

Ans :

Block P is experiencing a net force because the opposing horizontal forces acting on it are unequal. The net force on block P is 1 N to the right (5 N minus 4 N), meaning block P will continuously accelerate in the rightward direction according to Newton's second law. Block Q, moving at a constant velocity on a frictionless surface without any external arrows shown, has a net force of zero. According to Newton's first law, it will continue moving uniformly forever.

118. State Newton's third law of motion. Explain how a person is able to row a canoe forward through a lake using a paddle.

Ans :

Newton's third law of motion states that whenever one object exerts a force on a second object, the second object simultaneously exerts an equal and opposite force back on the first object. When rowing a canoe, the paddler uses the paddle to push the water forcefully in the backward direction. In response to this action, the water pushes the paddle—and consequently the canoe

Ans :

Given, Mass $m = 10 \text{ g} = \frac{10}{1000} \text{ kg} = 0.01 \text{ kg}$

Initial velocity $u = 150 \text{ ms}^{-1}$

Final velocity $v = 0 \text{ ms}^{-1}$

Time $t = 0.03 \text{ s}$

According to first equation of motion,

$$v = u + at$$

$$\begin{aligned} \text{Acceleration } a &= \frac{v - u}{t} = \frac{(0 - 150) \text{ ms}^{-1}}{0.03 \text{ s}} \\ &= -5000 \text{ ms}^{-2} \end{aligned}$$

(Negative sign indicates that the velocity of the bullet is decreasing.)

By second equation of motion :

$$\begin{aligned} s &= ut + \frac{1}{2} at^2 \\ &= 150 \text{ ms}^{-1} \times 0.03 \text{ s} + \frac{1}{2} \times (5000 \text{ ms}^{-2}) \times (0.03 \text{ s})^2 \\ &= 4.50 \text{ m} - 2.25 \text{ m} = 2.25 \text{ m} \end{aligned}$$

By second law of motion :

$$\begin{aligned} F &= m \times a \\ &= 0.01 \text{ kg} \times (5000 \text{ ms}^{-2}) \\ &= 50 \text{ N} \end{aligned}$$

Hence, the distance of penetration of the bullet into the block is 2.25 m and the magnitude of force exerted by the wooden block on the bullet is 50 N.

- 141.** An object of mass 1 kg travelling in a straight line with a velocity of 10 ms^{-1} collides with, and sticks to, a stationary wooden block of mass 5 kg. Then they both move off together in the same straight line. Calculate the total momentum just before the impact and just after the impact. Also, calculate the velocity of the combined object.

Ans :

Given, Mass of object $m_1 = 1 \text{ kg}$
Initial velocity $u_1 = 10 \text{ ms}^{-1}$

Mass of stationary wooden block $m_2 = 5 \text{ kg}$

Velocity of wooden block before collision,

$$u_2 = 0 \text{ m/s}$$

Let velocity of combined object = v

Force and Laws of Motion

Total momentum just before impact

$$\begin{aligned} &= m_1 \times u_1 \\ &= 1 \text{ kg} \times 10 \text{ ms}^{-1} \\ &= 10 \text{ kg ms}^{-1} \end{aligned}$$

By law of conservation of momentum,

Total momentum before impact

= Total momentum after impact

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

$$1(10) + 5(0) = (1 + 5) v$$

$$v = \frac{10}{6} = \frac{5}{3} \text{ ms}^{-1} = 1.67 \text{ ms}^{-1}$$

- 142.** An object of mass 100 kg is accelerated uniformly from a velocity of 5 ms^{-1} to 8 ms^{-1} in 6 s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object.

Ans :

Given,

Mass of object $m = 100 \text{ kg}$

Initial velocity $u = 5 \text{ ms}^{-1}$

Final velocity $v = 8 \text{ ms}^{-1}$

Time $t = 6 \text{ s}$

Initial momentum = $m \times u$

$$= 100 \text{ kg} \times 5 \text{ ms}^{-1}$$

$$= 500 \text{ kg ms}^{-1}$$

Final momentum = $m \times v$

$$= 100 \text{ kg} \times 8 \text{ ms}^{-1}$$

$$= 800 \text{ kg ms}^{-1}$$

$$\begin{aligned} F &= \frac{mv - mu}{t} \\ &= \frac{(800 - 500) \text{ kg ms}^{-1}}{6 \text{ s}} \\ &= \frac{300 \text{ kg ms}^{-1}}{6 \text{ s}} = 50 \text{ N} \end{aligned}$$

- 143.** How much momentum will a dumb-bell of mass 10 kg transfer to the floor if it falls from a height of 80 cm? Take its downward acceleration to be 10 ms^{-2} .

Ans :

Given, Mass $m = 10 \text{ kg}$

Final velocity $u = 0 \text{ ms}^{-1}$

Distance $s = 80 \text{ cm} = 0.8 \text{ m}$

Acceleration $a = 10 \text{ ms}^{-2}$

By third equation of motion :

$$v^2 - u^2 = 2as$$

$$v^2 - (0 \text{ ms}^{-1})^2 = 2 \times 10 \text{ ms}^{-2} \times 0.8 \text{ m}$$

We have, $400 = 0 \times 20 + \frac{1}{2} \times a \times 20^2 = 200 a$

$$a = \frac{400}{200}$$

or $a = 2 \text{ ms}^{-2}$

Now mass, $m = 7 \text{ metric ton}$

$$= 7,000 \text{ kg}; F = ?$$

Now, $F = ma = 7,000 \times 2$

or $F = 14,000 \text{ N}$

- 157.** A force of 5 N gives a mass m_1 , an acceleration of 8 ms^{-2} and a mass m_2 , an acceleration of 24 ms^{-2} . What acceleration would it give if both the masses are tied together?

Ans :

Let us first find mass m_1 and m_2 .

$$F = m_1 a_1$$

$$5 = m_1 (8)$$

or $m_1 = \frac{8}{5} \text{ kg}$

$$F = m_2 a_2$$

$$5 = m_2 (24) \text{ or } m_2 = \frac{5}{24} \text{ kg}$$

Total mass $M = (m_1 + m_2)$

$$\text{or } M = \frac{5}{8} + \frac{5}{24} = \frac{15+5}{24}$$

$$\text{or } M = \frac{20}{24} \text{ kg}$$

Let A be the acceleration produced in mass M .

$$F = m \times a$$

$$\text{or } 5 = \frac{20}{24} a$$

$$\text{or } a = \frac{5 \times 24}{20} = \frac{120}{20} = 6 \text{ ms}^{-2}$$

Hence, the acceleration of the combination is 6 ms^{-2} .

- 158.** A car of mass 1,000 kg moving with a velocity of 40 km h^{-1} collides with a tree and comes to stop in 5 s. What will be the force exerted by car on the tree?

Ans :

Given,

$$\text{Mass, } m = 1,000 \text{ kg}$$

$$\text{Initial velocity, } u = 40 \text{ kmh}^{-1} = \frac{100}{9} \text{ ms}^{-1}$$

$$\text{Final velocity, } v = 0$$

$$\text{Time, } t = 5 \text{ s}$$

As we know that,

$$F = ma$$

$$a = \frac{v - u}{t}$$

So,

$$= m \left[\frac{v - u}{t} \right]$$

$$= 1000 \left[\frac{0 - \frac{100}{9}}{5} \right]$$

or

$$= \frac{-20000}{9}$$

or

$$= -2,222 \text{ N}$$

- 159.** A bullet of mass 100 g is fired from a gun of mass 20 kg with a velocity of 100 ms^{-1} . Calculate the velocity of recoil of the gun.

Ans :

Given,

$$\text{Mass of bullet, } m = 100 \text{ g} = \frac{1}{10} \text{ kg}$$

$$\text{Velocity of bullet, } u = 100 \text{ ms}^{-1}$$

$$\text{Mass of gun, } M = 20 \text{ kg}$$

Let recoil velocity of gun = V

Before firing, the system (gun + bullet) is at rest, therefore, initial momentum of the system = 0

Final momentum of the system

$$= \text{momentum of bullet} + \text{momentum of gun}$$

$$= mu + MV = \frac{1}{10} \times 100 + 20 V$$

$$= 10 + 20 V$$

Apply law of conservation of momentum

$$\text{Final momentum} = \text{Initial momentum}$$

$$\text{i.e. } 10 + 20 V = 0$$

$$20 V = -10$$

or

$$V = -0.5 \text{ ms}^{-1}$$

Negative sign shows that the direction of recoil velocity of the gun is opposite to the direction of the velocity of the bullet.

- 160.** An iron sphere of mass 10 kg is dropped from a height of 80 cm. If the downward acceleration of the ball is 10 ms^{-2} , calculate the momentum transferred to the ground by the ball.

Ans :

Given,

$$\text{initial velocity of sphere, } u = 0$$

$$\text{Distance travelled, } s = 80 \text{ cm} = 0.8 \text{ m}$$

$$\text{Acceleration of sphere, } a = 10 \text{ ms}^{-2}$$

- 150.** A bullet of mass 10 g is fired from a rifle. The bullet takes 0.003 s to move through its barrel and leaves with a velocity of 300 ms⁻¹. What is the force exerted on the bullet by the rifle?

Ans :

Given, $m = 10 \text{ g} = 0.010 \text{ kg}$; $u = 0$; $v = 300 \text{ ms}^{-1}$,
 $t = 0.003 \text{ s}$, $F = ?$

As we know that

$$F = ma$$

$$F = m \frac{v - u}{t}$$

$$F = 0.010 \left(\frac{300 - 0}{0.003} \right)$$

or $F = 1,000 \text{ N}$

- 151.** What force would be needed to produce an acceleration of 1 ms⁻² on a ball of mass 1 kg?

Ans :

Given, mass, $m = 1 \text{ kg}$; acceleration, $a = 1 \text{ ms}^{-2}$
As we know that

Now $F = ma$

$$= 1 \times 1$$

or $F = 1 \text{ Newton}$

- 152.** What is the acceleration produced by a force of 5 N exerted on an object of mass 10 kg?

Ans :

Given, $F = 5 \text{ N}$; mass, $m = 10 \text{ kg}$; acceleration,
 $a = ?$

As we know that,

$$F = ma \text{ or } a = \frac{F}{m}$$

$$a = 0.5 \text{ ms}^{-2}$$

- 153.** How long should a force of 100 N act on a body of 20 kg so that it acquires a velocity of 100 ms⁻¹?

Ans :

Here $v - u = 100 \text{ ms}^{-1}$, $m = 20 \text{ kg}$; $F = 100 \text{ N}$; $t = ?$

We know $F = ma = m \frac{v - u}{t}$

or $t = m \left(\frac{v - u}{F} \right)$

$$= 20 \left(\frac{100}{100} \right) = 20 \text{ s}$$

- 154.** A 1,000 kg vehicle moving with a speed of 20 ms⁻¹ is brought to rest in a distance of 50 m, (i) Find the acceleration; (ii) Calculate the unbalanced force acting on the vehicle; (iii) The actual force applied by the brakes may be slightly less than that calculated. Why? Give reason.

Ans :

- (i) Given, $u = 20 \text{ ms}^{-1}$; $v = 0$; $s = 50 \text{ m}$; $a = ?$

Using $v^2 - u^2 = 2as$, we have

$$a = \frac{v^2 - u^2}{2s}$$

$$= \frac{0 - (20)^2}{2 \times 50}$$

$$= \frac{-400}{100} = -4 \text{ m/s}^2$$

- (ii) As we know that

$$F = ma = 1,000 \times (-4)$$

$$= -4,000 \text{ N}$$

- (iii) Due to force of friction, the actual force applied by brakes may be slightly less than calculated one.

- 155.** Which would require greater force : accelerating a 10 g mass at 5 ms⁻² or 20 g mass at 2 ms⁻²?

Ans :

In first case $m_1 = 10 \text{ g} = 0.010 \text{ kg}$;

Now $a_1 = 5 \text{ ms}^{-2}$; $F_1 = ?$

$$F_1 = m_1 a_1 = 0.010 \times 5$$

$$F_1 = 0.050 \text{ Newton}$$

In second case, $m_2 = 20 \text{ g} = 0.020 \text{ kg}$

$$a_2 = 2 \text{ ms}^{-2}; F_2 = ?$$

Now $F_2 = m_2 a_2 = 0.020 \times 2$

or $F_2 = 0.04 \text{ Newton}$

We find that $F_1 > F_2$, hence more force is required to accelerate 10 g at 5 ms⁻² than accelerating 20 g at 2 ms⁻².

- 156.** A truck starts from rest and rolls down a hill with constant acceleration. It travels a distance of 400 m in 20 s. Find its acceleration. Find the force acting on it if its mass is 7 metric ton.

Ans :

Given, $u = 0 \text{ ms}^{-1}$ (Starting from rest);

$$s = 400 \text{ m}; t = 20 \text{ s}; a = ?$$

Using $s = ut + \frac{1}{2}at^2$,

Final velocity $v = 8\text{m/s}$.

Time $t = 6\text{s}$.

Initial Momentum (p_i):

$$\begin{aligned} p_i &= mu \\ &= 100\text{kg} \times 5\text{m/s} \\ &= 500\text{kg m/s}. \end{aligned}$$

Final Momentum (p_f):

$$\begin{aligned} p_f &= mv \\ &= 100\text{kg} \times 8\text{m/s} \\ &= 800\text{kg m/s}. \end{aligned}$$

Magnitude of the force exerted (F):

Force can be calculated as the rate of change of momentum:

$$\begin{aligned} F &= \frac{(\text{Change in momentum})}{\text{Time}} \\ &= \frac{(p_f - p_i)}{t} \\ F &= \frac{(800\text{kg m/s} - 500\text{kg m/s})}{6\text{s}} \\ F &= \frac{300\text{kg m/s}}{6\text{s}} \\ &= 50\text{N}. \end{aligned}$$

Alternatively, first calculate acceleration:

$$\begin{aligned} a &= \frac{(v - u)}{t} \\ &= \frac{(8 - 5)}{6} \\ &= \frac{3}{6} = 0.5\text{m/s}^2. \end{aligned}$$

Then,

$$\begin{aligned} F &= ma \\ &= 100\text{kg} \times 0.5\text{m/s}^2 \\ &= 50\text{N}. \end{aligned}$$

The magnitude of the force exerted on the object is 50 Newtons.

- 174.** A hockey ball of mass 200 g travelling at 10 m/s is struck by a hockey stick so as to return it along its original path with a velocity of 5 m/s. Calculate the magnitude of change of momentum occurred in the motion of the hockey ball.

Ans :

Given,

Mass of hockey ball $m = 200\text{g} = 0.2\text{kg}$.

Initial velocity $u = 10\text{m/s}$.

Final velocity $v = -5\text{m/s}$ (since it returns along the original path, its direction is opposite).

Initial momentum

$$p_1 = mu$$

$$= 0.2\text{kg} \times 10\text{m/s}$$

$$= 2\text{kgm/s}.$$

Final momentum

$$\begin{aligned} p_2 &= mv \\ &= 0.2\text{kg} \times (-5\text{m/s}) \\ &= -1\text{kgm/s}. \end{aligned}$$

Change in momentum

$$\begin{aligned} \Delta p &= p_2 - p_1 \\ &= -1\text{kgm/s} - 2\text{kgm/s} \\ &= -3\text{kgm/s}. \end{aligned}$$

The magnitude of the change of momentum is 3 kg m/s.

- 175.** An automobile vehicle has a mass of 1500 kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of 1.7m/s^2 ?

Ans :

Given , Mass of the vehicle $m = 1500\text{kg}$.

Negative acceleration (retardation) $a = -1.7\text{m/s}^2$.

The force required to stop the vehicle is given by Newton's second law,

$$\begin{aligned} F &= ma. \\ F &= 1500\text{kg} \times (-1.7\text{m/s}^2) \\ F &= -2550\text{N}. \end{aligned}$$

The force between the vehicle and the road (primarily braking force and friction) must be 2550 N in the direction opposite to the vehicle's motion. The negative sign indicates this opposing direction.

- 176.** Two objects of masses 100 g and 200 g are moving along the same line and direction with velocities of 2 m/s and 1 m/s respectively. If they were to experience the same retarding force, which object would take longer to stop and why?

Ans :

Object 1: $m_1 = 0.1\text{kg}$, $u_1 = 2\text{m/s}$.

Momentum

$$\begin{aligned} p_1 &= 0.1 \times 2 \\ &= 0.2\text{kg.m/s}. \end{aligned}$$

Object 2: $m_2 = 0.2\text{kg}$, $u_2 = 1\text{m/s}$.

Momentum

$$\begin{aligned} p_2 &= 0.2 \times 1 \\ &= 0.2\text{kg.m/s}. \end{aligned}$$

Final velocity of sphere when it just reaches the ground can be calculated using

$$v^2 - u^2 = 2as$$

$$v^2 - 0 = 2 \times 10 \times 0.8$$

$$= 16$$

or $v = \sqrt{16} = 4 \text{ ms}^{-1}$.

Momentum of the sphere just before it touches the ground $= mv = 10 \text{ kg} \times 4 \text{ ms}^{-1} = 40 \text{ kg ms}^{-1}$

On reaching the ground, the iron sphere comes to rest, so its final momentum $= 0$

According to the law of conservation of momentum, Momentum transferred to the ground $=$ momentum of the sphere just before it comes to rest $= 40 \text{ kg ms}^{-1}$.

- 161.** Calculate the force required to impart to a car a velocity of 30 m/s in 10 s. The mass of the car is 1500 kg.

Ans :

Given, $u = 0$, $v = 30 \text{ m/s}$, $t = 10 \text{ s}$

As we know that

$$v = u + at$$

$$30 = 0 + a \times 10$$

$$a = 3 \text{ ms}^{-2}$$

Now $m = 1500 \text{ kg}$, $a = 3 \text{ ms}^{-2}$

Required Force (F) $= ma$

$$= 1500 \times 3 = 4500 \text{ N}$$

- 162.** A boy of mass 60 kg running at 3 m/s jumps on to a trolley of mass 140 kg moving with a velocity of 1.5 m/s in the same direction. What is their common velocity?

Ans :

For boy, $m_1 = 60 \text{ kg}$, $u_1 = 3 \text{ ms}^{-1}$, $v_1 = v$

For trolley, $m_2 = 140 \text{ kg}$, $u_2 = 1.5 \text{ ms}^{-1}$, $v_2 = v$

By conservation of momentum,

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

$$60 \times 3 + 140 \times 1.5 = (60 + 140) v$$

$$v = \frac{180 + 210}{200}$$

$$= \frac{390}{200} \text{ ms}^{-1}$$

$$= 1.95 \text{ ms}^{-1}$$

- 163.** A bullet of mass 20 g moving with a speed of 500 ms^{-1} strikes a wooden block of mass 1 kg and gets embedded in it. Find the speed with which block moves along with the bullet.

Ans :

For bullet, $m_1 = 20 \text{ g} = 0.02 \text{ kg}$, $u_1 = 500 \text{ ms}^{-1}$,

$$v_1 = v$$

For block, $m_2 = 1 \text{ kg}$, $u_2 = 0 \text{ ms}^{-1}$, $v_2 = v$

By conservation of momentum,

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

$$v = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}$$

$$= \frac{0.02 \times 500 + 1 \times 0}{0.02 + 1}$$

$$= \frac{10}{1.02} = \frac{1000}{102} = 9.8 \text{ ms}^{-1}$$

- 164.** A force of 0.6 N acting on a body increases its velocity from 5 m/s to 6 m/s in 2 s. Calculate the mass of the body.

Ans :

Given, $F = 0.6 \text{ N}$, $u = 5 \text{ ms}^{-1}$, $v = 6 \text{ ms}^{-1}$,

$$t = 2 \text{ s}$$

Acceleration $a = \frac{v - u}{t} = \frac{6 - 5}{2}$

$$= \frac{1}{2} \text{ ms}^{-2} = 0.5 \text{ ms}^{-2}$$

$$m = \frac{F}{a} = \frac{0.6}{0.5} = 1.2 \text{ kg}$$

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- 165.** Calculate the force needed to speed up a car with a rate of 5 ms^{-2} , if the mass of the car is 1000 kg.

Ans :

Given,

$$\text{Acceleration, } a = 5 \text{ m/s}^2$$

and Mass, $m = 1000 \text{ kg}$,

Therefore, Force, $F = ?$

We know that, $F = m \times a$

$$= 1000 \text{ kg} \times 5 \text{ m/s}^2$$

$$= 5000 \text{ kg m/s}^2$$

Therefore, required force

$$= 5000 \text{ kg m/s}^2 \text{ or } 5000 \text{ N}$$

- 166.** Two persons manage to push a motorcar of mass 1200 kg at a uniform velocity along a level road. The same motorcar can be pushed by three persons to produce an acceleration of 0.2 ms^{-2} . With what force does each person push the motorcar? (Assume that all persons push the motorcar with the same muscular effort)

Ans :

Mass of the motorcar = 1200 kg

Only two persons manage to push the car. Hence, the acceleration acquired by the car is given by the third person alone.

Acceleration produced by the car, when it is pushed by the third person,

$$a = 0.2 \text{ m/s}^2$$

Let the force applied by the third person be F .

From Newton's second law of motion :

$$\text{Force} = \text{Mass} \times \text{Acceleration}$$

$$F = 1200 \times 0.2 = 240 \text{ N}$$

Thus, the third person applies a force of magnitude 240 N.

Hence, each person applies a force of 240 N to push the motorcar.

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- 167.** A hammer of mass 500 g, moving at 50 ms^{-1} , strikes a nail. The nail stops the hammer in a very short time of 0.01 s. What is the force of the nail on the hammer?

Ans :

Mass of the hammer, $m = 500 \text{ g} = 0.5 \text{ kg}$

Initial velocity of the hammer, $u = 50 \text{ m/s}$

Time taken by the nail to stop the hammer, $t = 0.01 \text{ s}$

Velocity of the hammer, $v = 0$ (since the hammer finally comes to rest)

From Newton's second law of motion :

$$\begin{aligned} \text{Force, } f &= m \frac{v - u}{t} \\ &= 0.5 \frac{0 - 50}{0.01} \\ &= -2500 \text{ N} \end{aligned}$$

The hammer strikes the nail with a force of -2500 N . Hence, from Newton's third law of motion, the force of the nail on the hammer is equal and opposite, i.e., $+2500 \text{ N}$.

- 168.** A motorcar of mass 1200 kg is moving along a straight line with a uniform velocity of 90 km/h . Its velocity is slowed down to 18 km/h in 4 s by an unbalanced external force. Calculate the acceleration and change in momentum. Also calculate the magnitude of the force required.

Ans :

Mass of the motorcar, $m = 1200 \text{ kg}$

Initial velocity of the motorcar,

$$u = 90 \text{ km/h} = 25 \text{ m/s}$$

Final velocity of the motorcar,

$$v = 18 \text{ km/h} = 5 \text{ m/s}$$

Time taken, $t = 4 \text{ s}$

According to the first equation of motion :

$$v = u + at$$

$$5 = 25 + a(4)$$

$$a = -5 \text{ m/s}^2$$

Negative sign indicates that it's a retarding motion, i.e. velocity is decreasing.

Change in momentum = $mv - mu = m(v - u)$

$$= 1200(5 - 25)$$

$$= -24000 \text{ kg ms}^{-1}$$

Force = Mass $\times$ Acceleration

$$= 1200 \times -5$$

$$= -6000 \text{ N}$$

Acceleration of the motorcar = -5 m/s^2

Change in momentum of the motorcar

$$= -24000 \text{ kg ms}^{-1}$$

Hence, the force required to decrease the velocity is 6000 N .

(Negative sign indicates retardation, decrease in momentum and retarding force)

- 169.** A constant force acts on an object of mass 5 kg for a duration of 2 s . It increases the object's velocity from 3 m/s to 7 m/s . Find the magnitude of the applied force.

Ans :

Given: mass $m = 5 \text{ kg}$, time $t = 2 \text{ s}$, initial velocity $u = 3 \text{ m/s}$, final velocity $v = 7 \text{ m/s}$.

First, calculate acceleration (a):

$$\begin{aligned} a &= \frac{(v - u)}{t} \\ &= \frac{(7 \text{ m/s} - 3 \text{ m/s})}{2 \text{ s}} \end{aligned}$$

$$= \frac{4\text{m/s}}{2\text{s}}$$

$$= 2\text{m/s}^2$$

Now, calculate the force (F) using Newton's second law:

$$F = ma$$

$$F = 5\text{kg} \times 2\text{m/s}^2$$

$$= 10\text{N}.$$

The magnitude of the applied force is 10 Newtons.

- 170.** A motorcar is moving with a velocity of 108 km/h and it takes 4 s to stop after the brakes are applied. Calculate the force exerted by the brakes on the motorcar if its mass along with the passengers is 1000 kg.

Ans :

Initial velocity

$$u = 108\text{km/h}$$

$$= 108 \times \frac{1000\text{m}}{3600\text{s}}$$

$$= 30\text{m/s}.$$

Final velocity $v = 0\text{m/s}$ (stops). Time $t = 4\text{s}$.

Mass $m = 1000\text{kg}$.

$$\begin{aligned} \text{Acceleration } a &= \frac{(v - u)}{t} \\ &= \frac{(0 - 30\text{m/s})}{4\text{s}} \end{aligned}$$

$$= \frac{-30}{4}\text{m/s}^2$$

$$= -7.5\text{m/s}^2.$$

Force exerted by brakes

$$F = ma$$

$$= 1000\text{kg} \times (-7.5\text{m/s}^2)$$

$$= -7500\text{N}$$

The magnitude of the force is 7500 N. The negative sign indicates the force is opposite to the direction of motion.

- 171.** Which would require a greater force: accelerating a 2 kg mass at 5m/s^2 or a 4 kg mass at 2m/s^2 ? Justify your answer with calculations.

Ans :

Case 1: Mass $m_1 = 2\text{kg}$, acceleration $a_1 = 5\text{m/s}^2$.

Force

$$F_1 = m_1 a_1$$

$$= 2\text{kg} \times 5\text{m/s}^2$$

$$= 10\text{N}.$$

Case 2: Mass $m_2 = 4\text{kg}$, acceleration $a_2 = 2\text{m/s}^2$.

Force

$$F_2 = m_2 a_2$$

$$= 4\text{kg} \times 2\text{m/s}^2$$

$$= 8\text{N}.$$

Since $F_1(10\text{N}) > F_2(8\text{N})$, accelerating a 2 kg mass at 5m/s^2 would require a greater force.

- 172.** A stone of 1 kg is thrown with a velocity of 20 m/s across the frozen surface of a lake and comes to rest after travelling a distance of 50 m. What is the force of friction between the stone and the ice?

Ans :

Given, Mass of stone $m = 1\text{kg}$.

Initial velocity $u = 20\text{m/s}$.

Final velocity $v = 0\text{m/s}$ (comes to rest).

Distance travelled $s = 50\text{m}$.

First, we need to find the acceleration (retardation) of the stone using the third equation of motion:

$$v^2 = u^2 + 2as$$

$$0^2 = (20\text{m/s})^2 + 2 \times a \times 50\text{m}$$

$$0 = 400\text{m}^2/\text{s}^2 + 100a\text{m}$$

$$100a = -400\text{m}^2/\text{s}^2$$

$$a = \frac{-400}{100}\text{m/s}^2$$

$$= -4\text{m/s}^2.$$

The negative sign indicates that the acceleration is opposite to the direction of motion (retardation due to friction).

Now, the force of friction (F) can be calculated using Newton's second law:

$$F = ma.$$

$$F = 1\text{kg} \times (-4\text{m/s}^2)$$

$$= -4\text{N}$$

The magnitude of the force of friction is 4 N. The negative sign signifies that the frictional force acts in the direction opposite to the stone's motion.

- 173.** An object of mass 100 kg is accelerated uniformly from a velocity of 5 m/s to 8 m/s in 6 s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object.

Ans :

Given: Mass $m = 100\text{kg}$.

Initial velocity $u = 5\text{m/s}$.

$$v = 4 \text{ ms}^{-1}$$

Momentum transferred to the floor :

$$\begin{aligned} &= m \times v \\ &= 10 \text{ kg} \times 4 \text{ ms}^{-1} \\ &= 40 \text{ kg ms}^{-1} \end{aligned}$$

- 144.** When a force of 40 N is applied on a body it moves with an acceleration of 5 ms^{-2} . Calculate the mass of the body.

Ans :

Let m be the mass of the body.

Given : $F = 40 \text{ N}$, $a = 5 \text{ ms}^{-2}$

From the relation $F = m a$, we have

$$\begin{aligned} 40 &= m \times 5 \\ m &= \frac{40}{5} = 8 \text{ kg} \end{aligned}$$

- 145.** An object undergoes an acceleration of 8 ms^{-2} starting from rest. Find the distance travelled in 1 second.

Ans :

Given,

Acceleration, $a = 8 \text{ ms}^{-2}$

Initial velocity, $u = 0$

Time interval, $t = 1 \text{ s}$

Distance travelled, $s = ?$

Using the equation of motion,

$$\begin{aligned} s &= ut + \frac{1}{2}at^2, \text{ we get} \\ s &= 0 \times 1 + \frac{1}{2} \times 8 \times 1^2 = 4 \text{ m} \end{aligned}$$

The object travels a distance of 4 m.

- 146.** It is required to increase the velocity of a scooter of mass 80 kg from 5 ms^{-1} to 25 ms^{-1} in 2 seconds. Calculate the force required.

Ans :

Given,

Mass of scooter, $m = 80 \text{ kg}$,

Initial velocity, $u = 5 \text{ ms}^{-1}$

Final velocity, $v = 25 \text{ ms}^{-1}$

and $t = 2 \text{ s}$

Now acceleration $a = \text{change in velocity time}$

$$\begin{aligned} &= \frac{v - u}{t} \\ &= \frac{25 - 5}{2} = 10 \text{ ms}^{-2} \end{aligned}$$

Force = mass $\times$ acceleration

$$= ma$$

Therefore, $F = 80 \times 10 = 800 \text{ N}$

- 147.** Calculate the force required to impact to a car, a velocity of 30 ms^{-1} in 10 seconds. The mass of the car is 1,500 kg.

Ans :

Given, $u = 0 \text{ ms}^{-1}$; $v = 30 \text{ ms}^{-1}$; $t = 10 \text{ s}$; $a = ?$

Using $v = u + at$, we have

$$\begin{aligned} 30 &= 0 + a(10) \\ a &= 3 \text{ ms}^{-2} \end{aligned}$$

Now $F = ma = 1,500 \times 3$

or $F = 4,500 \text{ N}$

- 148.** A cricket ball of mass 70 g moving with a velocity of 0.5 ms^{-1} is stopped by player in 0.5 s. What is the force applied by player to stop the ball?

Ans :

Given,

Mass of ball, $m = 70 \text{ g} = 0.070 \text{ kg}$;

Initial velocity, $u = 0.5 \text{ ms}^{-1}$;

Final velocity, $v = 0$

Time, $t = 0.5 \text{ s}$

As we know that, $F = ma$

$$F = m \left(\frac{v - u}{t} \right)$$

$$\text{or } F = 0.07 \left(\frac{0 - 0.50}{0.5} \right)$$

$$\text{or } F = -0.07 \text{ newton}$$

The negative sign indicates that the force exerted by the player is opposite to the direction of motion of the ball.

- 149.** What will be acceleration of a body of mass 5 kg if a force of 200 N is applied to it?

Ans :

Given, mass, $m = 5 \text{ kg}$; Force, $F = 200 \text{ N}$

As we know that

$$F = ma \text{ or } a = \frac{F}{m}$$

$$a = \frac{F}{m} = \frac{200}{5} = 40 \text{ ms}^{-2}$$

$$a = 40 \text{ ms}^{-2}$$

Both objects have the same initial momentum (0.2 kg m/s).

From Newton's second law,

$$\text{Force} = \frac{\text{Change in momentum}}{\text{Time}},$$

$$\text{So, Time} = \frac{\text{Change in momentum}}{\text{Force}}.$$

Since both objects stop (final momentum = 0), the change in momentum is the same for both (−0.2 kg m/s). If they experience the same retarding force, they will take the same amount of time to stop.

177. A bullet of mass 10 g is fired from a gun of mass 5 kg with a velocity of 300 m/s. Calculate the recoil velocity of the gun. (Assume the net momentum before firing is zero).

Ans :

Mass of bullet $m_b = 10\text{g} = 0.01\text{kg}$.

Velocity of bullet $v_b = 300\text{m/s}$.

Mass of gun $m_g = 5\text{kg}$.

Let recoil velocity of gun be v_g .

By conservation of momentum, total initial momentum = total final momentum.

Initial momentum (before firing) = 0 (gun and bullet are at rest).

Final momentum

= momentum of bullet + momentum of gun

$$= m_b v_b + m_g v_g.$$

$$0 = (0.01\text{kg} \times 300\text{m/s}) + (5\text{kg} \times v_g).$$

$$0 = 3\text{kg m/s} + 5v_g.$$

$$5v_g = -3\text{kg m/s}.$$

$$v_g = -3/5\text{m/s} = -0.6\text{m/s}.$$

The recoil velocity of the gun is 0.6 m/s in the direction opposite to the bullet.

CASE BASED QUESTIONS

178. Rohan and his family were driving to a remote hill station when their car engine suddenly stopped working on a flat highway. Rohan and his father stepped out and tried to push the car forward from the back while his mother steered. At first, despite both of them pushing as hard as they could, the heavy car did not move an inch. Another driver saw them struggling and stopped his vehicle to help. When all three of them pushed together in the same forward direction,

the car finally started rolling slowly down the road. Rohan wondered why his and his father's combined physical strength was not enough, but the addition of just one more person made the stalled vehicle move.

QUESTIONS:

- Why did the car not move initially when only Rohan and his father were pushing it?
- What was the direction of the force of friction acting on the car when it finally started moving forward?
- Explain the condition required for the car to change its state from rest to motion in terms of net force.

Ans :

- The car did not move initially because the forward force applied by Rohan and his father was balanced by the opposing force of friction from the road. The net force acting on the car was zero.
- The force of friction acts in the direction opposite to the motion. Therefore, when the car moved forward, the friction acted in the backward direction.
- To change an object's state from rest to motion, an unbalanced force must act upon it. This means the total applied force in the forward direction must be greater than the opposing frictional force, resulting in a non-zero net force in the direction of motion.

179. Meera was preparing a science fair project to demonstrate how different materials affect motion. She set up a small wooden ramp and let a battery-free toy car roll down it. She tested the car's movement on three different flat horizontal surfaces placed at the bottom of the ramp: a smooth polished marble floor, a rough concrete pathway, and a thick woolen carpet. She made sure to release the car from the exact same height on the ramp every time. She carefully recorded the distance the car travelled on each surface before coming to a complete stop and noticed drastic differences in her measurements across the three trials.

QUESTIONS:

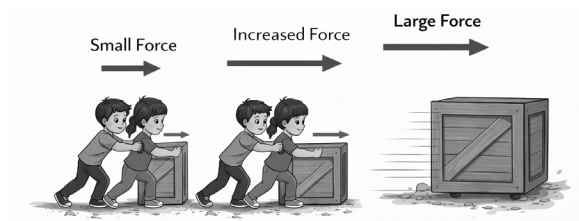
- On which of the three surfaces will the toy car travel the maximum distance, and why?
- Identify the unseen force that causes the moving toy car to eventually stop on the flat surfaces.

- (c) If Meera applied a thick layer of lubricating oil on the polished marble floor before the experiment, how would it affect the distance travelled by the car?
- (d) Based on Newton's first law of motion, what would happen to the rolling car if the opposing force on the floor could magically be reduced to absolute zero?

Ans :

- (a) The toy car will travel the maximum distance on the smooth polished marble floor. This is because the marble floor offers the least amount of surface roughness, resulting in the smallest force of friction opposing the car's motion.
- (b) The unseen force that causes the moving toy car to stop is the force of friction, which arises between the wheels of the car and the surface it is moving on.
- (c) Applying lubricating oil would make the marble surface even smoother, further reducing the force of friction. As a result, the toy car would travel an even greater distance before coming to a stop.
- (d) If the opposing force of friction were reduced to absolute zero, the net force acting horizontally on the car would be zero. According to Newton's first law, the car would continue moving forever in a straight line with a constant velocity.

180. Two children are trying to push a very heavy wooden box across a rough floor. Initially, they apply a small force, but the box does not move. They increase their pushing force, but the box still remains stationary. Finally, when they push with all their might, the box just begins to slide.



- When the children applied a small force and the box did not move, what force was opposing their push?
- Were the forces acting on the box balanced or unbalanced when it was stationary despite the children pushing? Explain.

- What changed when the children pushed with all their might and the box started to move, in terms of the forces acting on it?
- Which of Newton's laws of motion best describes the initial state of the box (at rest) and its tendency to remain at rest?

Ans :

- The force opposing their push was the force of friction between the bottom of the box and the rough floor.
- When the box was stationary despite the children pushing, the forces acting on it were balanced. The pushing force applied by the children was equal and opposite to the frictional force.
- When the children pushed with all their might and the box started to move, their applied pushing force became greater than the maximum frictional force. This resulted in an unbalanced force acting on the box in the direction of their push, causing it to accelerate and move.
- Newton's First Law of Motion (Law of Inertia) best describes the initial state of the box and its tendency to remain at rest unless acted upon by an unbalanced force.

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181. Captain Anya was conducting a spacewalk outside the International Space Station to repair a broken external solar panel. She observed that objects outside the station did not fall downwards because there was no strong gravitational pull acting as it does near Earth's surface. During the repair, after a slight accidental bump from her heavy metallic wrench, a small bolt slipped from her glove. The small bolt drifted away into the dark vacuum of space in a perfectly straight line. It maintained exactly the same speed without ever slowing down, leaving Anya to watch it disappear slowly into the vast distance over several minutes.

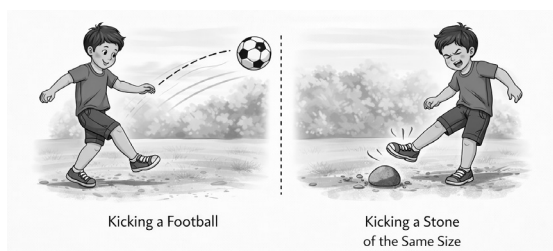
QUESTIONS:

- Why did the metallic bolt continue moving in a straight line without slowing down?
- State Newton's law of motion that perfectly describes the behaviour of the drifting bolt.
- What is the magnitude of the net force acting on the drifting bolt while it moves through deep space with constant velocity?

Ans :

- The bolt continued moving at a steady speed in a straight line because space is a vacuum with no air resistance or friction to oppose its motion and change its velocity.
- Newton's first law of motion describes this behaviour. It states that an object in motion continues to move with a constant velocity unless a net force acts upon it.
- Since the bolt is moving with a constant velocity (constant speed in a straight line), its acceleration is zero. Therefore, the net force acting on the drifting bolt is exactly zero.

- 182.** A child kicks a football, and it flies a considerable distance. If the same child kicks a stone of the same size with what they perceive to be the same effort (force), the stone hardly moves, and the child might even hurt their foot.



- Which object, the football or the stone, has more inertia?
- How is inertia related to the mass of an object?
- Explain why the football moves a greater distance than the stone when kicked with similar effort.
- If the child wanted to give the stone the same acceleration as the football, would they need to apply less, more, or the same force? Which law explains this?

Ans :

- The stone has more inertia than the football.
- Inertia is directly proportional to the mass of an object. The more massive an object, the greater its inertia.
- The football moves a greater distance because it has less mass (and therefore less inertia) than the stone. For a similar applied force, the less massive object will experience a greater change in its state of motion (greater acceleration).
- To give the more massive stone the same acceleration as the football, the child would need to apply a greater force. This is explained by Newton's Second Law of Motion ($F = ma$)

- 183.** In a busy logistics warehouse, a worker named Tariq uses a mechanical pusher machine to move heavy supply crates along a very smooth metal track. The pusher machine is specifically programmed to apply a constant horizontal force of 200 N every time a button is pressed. Tariq first uses the machine to push a wooden crate having a mass of 40 kg. Later in his shift, he uses the exact same machine setting to push a much larger metal crate having a mass of 100 kg. He observes that while both crates start moving forward, the wooden crate picks up speed much more rapidly than the heavy metal crate.

QUESTIONS:

- Calculate the acceleration produced in the 40 kg wooden crate when the pusher applies its force.
- What fundamental relationship between mass and acceleration is demonstrated in Tariq's observation?
- If Tariq wanted the 100 kg metal crate to accelerate at the exact same rate as the 40 kg crate, what must he do to the applied force?
- Write the mathematical equation for Newton's second law of motion that connects force, mass, and acceleration.

Ans :

- Using the formula $a = F / m$, the acceleration is $200 \text{ N} / 40 \text{ kg} = 5 \text{ m s}^{-2}$.
- Tariq's observation demonstrates that for a given constant force, acceleration is inversely proportional to the mass of the object. A larger mass results in a smaller acceleration.
- To make the 100 kg crate accelerate at 5 m s^{-2} , he would need to increase the applied force. The required force would be

$$F = m \times a = 100 \text{ kg} \times 5 \text{ m s}^{-2} = 500 \text{ N}.$$
- The mathematical equation for Newton's second law is $F = ma$, where F is the net force, m is the mass, and a is the acceleration.

- 184.** During a state gymnastics training camp, Coach Sharma noticed that the junior athletes were complaining about knee and ankle pain after practicing their vault landings. They had been landing directly on a thin, hard rubber mat placed over the concrete floor. Coach Sharma immediately replaced the thin mat with a highly compressible, thick foam crash mat. He explained to the young gymnasts that the new mat would

Ans :

- The sudden backward jerk of the gun is called the recoil of the gun.
- According to Newton's third law of motion, the magnitudes of the action force on the bullet and the reaction force on the gun are exactly equal.
- Although the forces are equal in magnitude, they act on objects with very different masses. According to Newton's second law ($a = F/m$), acceleration is inversely proportional to mass. Since the bullet has a tiny mass, it gets a massive acceleration, whereas the heavy rifle has a large mass and therefore experiences a much smaller backward acceleration.

189. A car with a dead battery needs to be pushed. One person tries to push it but can't get it to move. When two people push, the car slowly starts to accelerate. The mass of the car is 1000 kg. When the two people push, they exert a combined constant force that results in the car accelerating at 0.05 m/s^2 .



- What was the net force on the car when only one person was pushing and it didn't move?
- When two people push and the car accelerates at 0.05 m/s^2 , what is the magnitude of the net unbalanced force acting on the car? (Use Newton's Second Law).
- If the frictional force opposing the car's motion is 100 N, what is the total force applied by the two people when the car is accelerating at 0.05 m/s^2 ?
- If the same net unbalanced force found in Q₂ was applied to a smaller car of mass 500 kg, what would be its acceleration?

Ans :

- When only one person was pushing and the car didn't move, the net force on the car was zero. The pushing force was balanced by the frictional force.
- Net unbalanced force

$$F = ma$$

$$= 1000\text{kg} \times 0.05\text{m/s}^2 = 50\text{N}.$$

- Net force = Applied force - Frictional force.

$$\text{So, Applied force} = \text{Net force} + \text{Frictional force}$$

$$= 50 \text{ N} + 100 \text{ N} = 150 \text{ N}.$$

- Acceleration $a = F/m$
- $$= 50\text{N}/500\text{kg} = 0.1\text{m/s}^2.$$

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190. A software engineering team was conducting a field test for a lightweight automated delivery drone. A monitoring device recorded the drone's flight data and generated a velocity-time graph on a laptop screen for the engineers to analyze. The graph showed a straight line sloping upwards starting from the zero mark for the first five seconds. Then, the graph became a completely straight horizontal line parallel to the time axis for the next ten seconds. Finally, the graph showed a straight line sloping downwards until it touched the zero velocity mark again, indicating the drone had landed safely.

QUESTIONS:

- What type of motion does the drone exhibit during the first five seconds when the graph line slopes upwards?
- Is there a net force acting on the drone during the period when the graph is a straight horizontal line? Justify your answer.
- What does the downward sloping line in the final part of the graph indicate about the drone's acceleration?
- According to Newton's first law, what is the required condition for the drone to maintain the horizontal line phase of the graph?

Ans :

- During the first five seconds, the upward sloping velocity-time graph indicates that the drone is moving with constant acceleration (velocity is increasing at a steady rate).
- No, there is no net force acting on the drone during the horizontal line phase. A horizontal velocity-time graph means the velocity is constant (acceleration is zero), which, according to Newton's second law ($F=ma$), means the net force must be zero.
- The downward sloping line indicates that the velocity is decreasing over time. This means the drone is undergoing negative acceleration or retardation as it prepares to land.

QUESTIONS:

- When Anita pushed her feet backward against the starting block, which force propelled her forward into the pool?
- State the law of motion that governs Anita's forward movement both at the dive and while swimming.
- Identify the action and reaction forces occurring when Anita uses her hands to swim through the water.
- Do the action and reaction forces in this swimming scenario cancel each other out? Provide a reason for your answer.

Ans :

- When Anita pushed backward, the starting block exerted an equal and opposite reaction force forward on her feet, propelling her into the pool.
- This is governed by Newton's third law of motion, which states that to every action, there is an equal and opposite reaction.
- The action force is Anita's hands pushing the water backward. The reaction force is the water pushing Anita's hands (and thus her body) forward with an equal magnitude.
- No, the action and reaction forces do not cancel each other out. This is because they act on two completely different objects (Anita's hands and the water), whereas forces only cancel out if they are balanced on the same object.

- 187.** When a bullet is fired from a gun, the gun moves backward, or "recoils." The forward force exerted on the bullet is accompanied by an equal and opposite force exerted by the bullet on the gun. The mass of the gun is significantly larger than the mass of the bullet.



- Which of Newton's laws of motion explains the recoil of the gun?
- Are the force exerted on the bullet and the recoil force on the gun equal in magnitude? Are they in the same or opposite directions?

- Why is the acceleration of the gun much less than the acceleration of the bullet, even though the forces are equal in magnitude?
- If the gun and bullet system is considered isolated, what can be said about the total momentum of the system before and after firing (if initially at rest)?

Ans :

- Newton's Third Law of Motion explains the recoil of the gun (for every action, there is an equal and opposite reaction).
- Yes, the force exerted on the bullet (action) and the recoil force on the gun (reaction) are equal in magnitude but opposite in direction.
- The acceleration of the gun is much less than the acceleration of the bullet because the gun has a much larger mass than the bullet ($a = F/m$). For the same force, a larger mass results in smaller acceleration.
- If the system is isolated and initially at rest, the total momentum of the system (gun + bullet) before firing is zero. Due to the law of conservation of momentum, the total momentum of the system after firing also remains zero (the forward momentum of the bullet is balanced by the backward momentum of the gun).

- 188.** Inspector Vikram was testing a newly issued sniper rifle at the police outdoor firing range. He carefully aimed at a paper target 200 meters away and pulled the trigger. Immediately, he felt a powerful, sudden backward jerk against his right shoulder, while the small metallic bullet blasted forward out of the barrel at a supersonic speed. Vikram knew that the explosive gases expanding inside the barrel applied a massive forward force on the bullet. Because of this, he always made sure to hold the heavy gun tightly against his body to manage the inevitable backward kick safely.

QUESTIONS:

- What term is commonly used in physics to describe the sudden backward jerk of the gun experienced by Inspector Vikram?
- According to Newton's third law, are the magnitudes of the force exerted on the forward-moving bullet and the force exerted on the backward-moving gun equal or different?
- Why does the small bullet accelerate forward at a massive speed, while the heavy rifle only accelerates backward slightly, despite experiencing the same magnitude of force?

cushion their fall by sinking inwards deeply when they landed on it. After the equipment switch, the athletes found the landings much softer and reported no further joint pain during their daily practice sessions.

QUESTIONS:

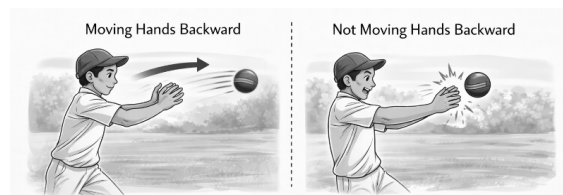
- What happens to the final velocity of a gymnast when they land and come to a complete stop on the mat?
- How does the thick compressible foam mat change the time duration of the gymnast's landing compared to the hard rubber mat?
- Explain how this change in time duration affects the acceleration (or deceleration) of the landing gymnast.
- Using Newton's second law of motion, justify why a smaller acceleration reduces the risk of joint injury.
- Give one other real-life application, similar to the concept of the crash mat, used in modern passenger vehicles to protect people during collisions.

Ans :

- When the gymnast lands and comes to a complete stop on the mat, their final velocity becomes zero.
- The thick compressible foam mat increases the time duration over which the gymnast's velocity reduces to zero, as it takes time for the mat to compress.
- Because acceleration is the rate of change of velocity, increasing the time taken to stop reduces the magnitude of acceleration (or deceleration) experienced by the gymnast.
- According to Newton's second law, force is directly proportional to acceleration ($F = ma$). A smaller acceleration means a smaller net force is exerted by the mat on the gymnast's legs, which minimizes the impact and reduces the risk of joint injury.
- Airbags provided in vehicles are a similar application. They inflate during a collision to increase the time over which a passenger comes to a halt, thereby reducing the force exerted on them.

185. A fielder in a cricket match sees a fast-moving cricket ball coming towards him. To catch it, he moves his hands backward in the direction of the ball's motion while making contact and bringing it to rest. If he tried to stop the ball abruptly

without moving his hands back, the impact would be much harder and could hurt his hands.



- What physical quantity of the cricket ball is significantly changed when the fielder catches it?
- By moving his hands backward, what does the fielder increase – the force of impact or the time taken to stop the ball?
- According to Newton's Second Law of Motion (related to momentum), how does increasing the time of impact affect the force experienced by the fielder's hands? (Force = Rate of change of momentum).
- Give another real-life example where the time of impact is increased to reduce the force.

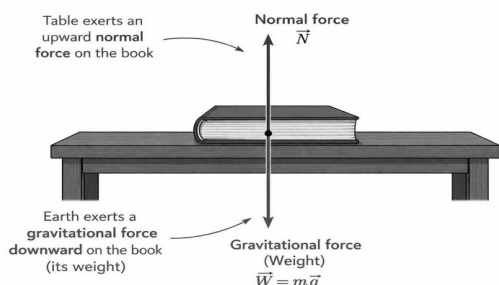
Ans :

- The momentum of the cricket ball is significantly changed (from a high value to zero).
- By moving his hands backward, the fielder increases the time taken to stop the ball (i.e., to reduce its momentum to zero).
- Increasing the time of impact (during which the momentum changes) decreases the rate of change of momentum. Since force is proportional to the rate of change of momentum, this reduces the force experienced by the fielder's hands.
- Another example is high jumpers landing on a cushioned mat or sand pit, which increases the time it takes for them to come to rest, reducing the force of impact on their bodies. Also, cars have crumple zones that increase the time of impact during a collision.

186. At the regional swimming championship, Anita was positioned at the edge of the pool waiting for the starting whistle. When the loud whistle blew, she forcefully pushed her feet backward against the rough starting block. Instantly, her body shot forward through the air and dived cleanly into the water. As she swam the freestyle stroke, she continuously pushed the water backward with her cupped hands and kicking feet. This constant repetitive action allowed her to glide forward rapidly through the water and eventually win the gold medal in the 100-meter freestyle race.

- (d) To maintain constant velocity (the horizontal line phase), Newton's first law states that the net external force acting on the drone must be strictly zero. The thrust from the propellers must perfectly balance air resistance and gravity.

191. A book is resting on a horizontal table. The Earth exerts a gravitational force downwards on the book (its weight). The table exerts an upward normal force on the book.



1. According to Newton's Third Law, what is the reaction force to the Earth's gravitational pull on the book? On which object does this reaction force act?
2. What is the reaction force to the upward normal force exerted by the table on the book? On which object does this reaction force act?
3. Are the gravitational force on the book and the normal force from the table an action-reaction pair according to Newton's Third Law? Why or why not?
4. If the book is at rest, what is the relationship between the magnitude of the gravitational force on the book and the normal force from the table?

Ans :

1. The reaction force to the Earth's gravitational pull on the book is an equal and opposite gravitational pull exerted by the book on the Earth. This force acts on the Earth.
2. The reaction force to the upward normal force exerted by the table on the book is an equal and opposite downward force exerted by the book on the table. This force acts on the table.
3. No, the gravitational force on the book (by Earth) and the normal force on the book (by the table) are not an action-reaction pair according to Newton's Third Law. This is because both forces act on the same object

(the book). An action-reaction pair always acts on two different objects.

4. If the book is at rest, the gravitational force on the book and the normal force from the table are equal in magnitude and opposite in direction (they are balanced forces acting on the book).

192. In a high school physics laboratory, Mr. Iyer performed a simple demonstration for his students. He placed a strong bar magnet on a wooden table and brought a small iron nail close to it. The nail instantly leaped across the gap and stuck firmly to the magnet. Next, he dropped a ripe apple from his hand, and it fell straight to the floor. He explained to the curious class that just as the Earth pulls the apple downwards, the apple also pulls the Earth upwards. Similarly, the magnet pulls the nail, and the nail also pulls the magnet.

QUESTIONS:

- (a) Does Newton's third law of motion apply only to contact forces like pushing a box, or does it also apply to non-contact forces?
- (b) When the iron nail leaps towards the magnet, does the nail exert a force on the magnet? If yes, what is its magnitude relative to the magnet's pull?
- (c) If the falling apple pulls the Earth upwards with an equal gravitational force, why do we only see the apple falling, but never see the Earth moving towards the apple?

Ans :

- (a) Newton's third law applies to all types of forces, including both contact forces (like pushing) and non-contact forces (like magnetic and gravitational forces).
- (b) Yes, the nail exerts a magnetic force on the magnet. According to Newton's third law, this force is exactly equal in magnitude and opposite in direction to the force exerted by the magnet on the nail.
- (c) We do not see the Earth moving towards the apple because the mass of the Earth is unimaginably large compared to the apple. Although the upward force on the Earth is equal to the downward force on the apple, the resulting acceleration of the Earth ($a = F/m$) is so infinitesimally small that it cannot be noticed or measured.

193. Little Aarav was playing with his new wooden toy train set on a smooth, polished track in his living room. The toy set consisted of a battery-motorized engine car tied to two passenger cabins behind it using thin, light cotton strings. When Aarav switched the engine on, it generated a forward pulling force, and the entire train—engine and both passenger cabins—began to accelerate together down the track. His older sister explained that to find out how fast the whole train speeds up, they did not have to calculate forces for each car individually. Instead, they could imagine the engine, the cabins, and the strings as one single combined object.

QUESTIONS:

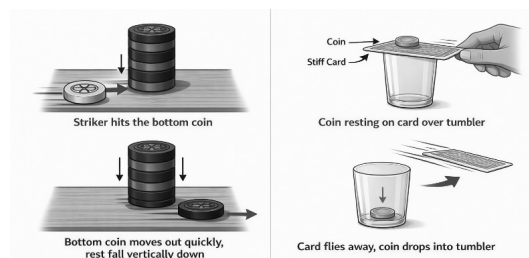
- When analyzing the engine, cabins, and strings as a single combined system, does the tension in the cotton strings count as an internal or external force?
- What is the external force that causes the entire train system to accelerate forward?
- If the total combined mass of the train system is 2 kg and the engine applies a net forward external force of 4 N, what will be the acceleration of the train?
- How does the upward normal force acting on the train system from the track behave in relation to the downward gravitational force?
- If Aarav adds a heavy wooden block into one of the passenger cabins, what will happen to the overall acceleration of the train system, assuming the engine's forward force remains exactly the same?

Ans :

- When treating the entire train as a single system, the tension forces acting in the connecting cotton strings are considered internal forces and cancel each other out.
- The external force is the forward force generated by the motorized engine against the track that propels the system forward.
- Using the formula $a = F / \text{mass of the system}$, the acceleration will be $4 \text{ N} / 2 \text{ kg} = 2 \text{ m/s}^2$.
- The normal force acting upwards on the system balances exactly with the total gravitational force (weight) acting downwards on the system, meaning there is zero vertical acceleration.
- Adding a heavy wooden block increases the total mass of the system. Since acceleration

is inversely proportional to mass for a given force ($a = F/m$), the overall acceleration of the train system will decrease.

- 194.** When a pile of carom coins is struck hard at the bottom by a striker, only the bottom coin moves out quickly, and the rest of the pile falls vertically down. Similarly, when a glass tumbler is covered with a stiff card and a coin is placed on the card, flicking the card sharply causes the card to fly away while the coin drops into the tumbler.



- What property of the coins (in the pile, excluding the bottom one) and the coin (on the card) causes them to behave this way?
- Explain the behavior of the carom coin pile using the concept of inertia.
- Explain the behavior of the coin and card using the concept of inertia.
- If the striker hit the carom coin pile very slowly, would the outcome likely be the same? Why or why not?

Ans :

- The property is inertia – their tendency to resist a change in their state of rest.
- When the bottom coin is struck and moves out quickly, the inertia of the remaining coins in the pile makes them tend to stay at rest. Since their support (the bottom coin) is removed, they fall vertically downwards due to gravity.
- When the card is flicked, it moves away quickly. The coin, due to its inertia, tends to remain in its state of rest. As the card is no longer supporting it, the coin falls vertically into the tumbler due to gravity.
- If the striker hit the pile slowly, the frictional forces between the coins might be enough to cause the entire pile to move together with the striker, rather than just the bottom coin shooting out. The quick, sharp hit minimizes the time for force transfer to the upper coins via friction..

195. A passenger is standing in a bus that is initially at rest. When the bus suddenly starts moving forward, the passenger tends to fall backward. Later, when the bus is moving at a constant speed and suddenly applies brakes, the passenger tends to fall forward.

1. Explain why the passenger tends to fall backward when the bus suddenly starts moving forward. Which law of motion is applicable here?
2. Explain why the passenger tends to fall forward when the moving bus suddenly stops.
3. What property of the passenger's body is responsible for these experiences?
4. How do safety belts in a car help prevent injuries related to this phenomenon when brakes are applied suddenly?

Ans :

1. When the bus starts moving forward, the lower part of the passenger's body (feet in contact with the bus floor) moves forward with the bus. However, due to inertia, the upper part of the body tends to remain at rest. This causes the passenger to feel a jerk and fall backward. Newton's First Law of Motion (Law of Inertia) is applicable here.
2. When the moving bus suddenly stops, the lower part of the passenger's body comes to rest with the bus. However, due to inertia, the upper part of the body tends to continue moving forward. This causes the passenger to fall forward.
3. The property of the passenger's body responsible for these experiences is inertia – the tendency to resist a change in its state of motion or rest.
4. Safety belts exert a force on the passenger's body when brakes are applied suddenly, preventing the passenger from continuing to move forward due to inertia, thereby reducing the risk of collision with the car's interior and injury.

196. A truck moving at 5 m/s can cause much more damage upon collision than a bicycle moving at the same speed. A bullet fired from a gun has a small mass but can have a devastating impact due to its high velocity. These observations led Newton to introduce the concept of momentum.

1. How is the momentum of an object defined mathematically?
2. What are the SI units of momentum?

3. Why does a moving truck have more momentum than a bicycle moving at the same speed?
4. Newton's Second Law can also be stated in terms of momentum. What is this statement?

Ans :

1. The momentum (p) of an object is defined as the product of its mass (m) and its velocity (v): $p = mv$.
2. The SI unit of momentum is kilogram-meter per second (kg m/s).
3. A moving truck has more momentum than a bicycle at the same speed because the truck has a much larger mass. Since momentum is mass times velocity, a larger mass results in larger momentum for the same velocity.
4. Newton's Second Law states that the rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of the force.

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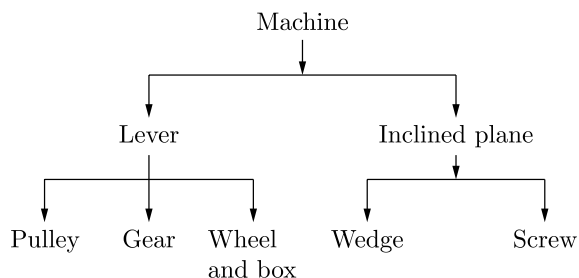
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3. MACHINES

Machine is a device which acts as a force multiplier or speed multiplier allowing us to apply effort at a more convenient point in an easier direction.

Simple machines can be classified into two major classes, *i.e.* the lever and the inclined plane. But after modification into many other simple machines, the classification is of the following form:



- (i) Load (L) is the resistance overcome by the machine.
- (ii) Effort (E) is the force applied to overcome the resistance (or load).

3.1 Important Terms of Machine

Some important terms related to machine are as follows :

1. The mechanical advantage of a machine is the ratio of the load overcome to the effort applied, *i.e.*

$$\text{Mechanical Advantage (MA)} = \frac{\text{Load}(L)}{\text{Effort}(E)}$$

2. The velocity ratio of a machine is defined as the ratio of velocity of the effort to the velocity of the load.

$$\text{Velocity Ratio (VR)} = \frac{\text{Velocity of effort}(V_E)}{\text{Velocity of load}(V_L)}$$

3. If V_E , V_L are the velocities and d_E and d_L are the displacements of the effort and load respectively acting for a time t , then

$$VR = \frac{(d_E/t)}{(d_L/t)} = \frac{d_E}{d_L}$$

4. No machine works by itself. The work is to be done by the effort E on the machine which is called the work input. *i.e.*

$$W_i = \text{effort } (E) \times \text{displacement of the effort } (d_E).$$

5. The work done by the machine in overcoming resistance or raising the load L is the work output. *i.e.*

$$W_o = \text{load } (L) \times \text{displacement of the load } (d_L)$$

6. For an ideal (perfect) machine

$$\text{Work output } (W_o) = \text{Work input } (W_i)$$

$$\text{or Power output } (P_o) = \text{Power input } (P_i)$$

7. The efficiency of a machine is defined as the ratio of the useful work done by the machine to the total work put into the machine in a specific time.

$$\eta = \frac{\text{Output power}(P_o)}{\text{Input power}(P_i)}$$

Use work done by machine

$$\eta = \frac{\text{on load a certain time}(W_o)}{\text{Total work put into the machine by effort in the same time } (W_i)}$$

$$\eta = \frac{\text{Work output}(W_o)}{\text{Work input}(W_i)}$$

The efficiency of an ideal machine is 1 or 100%. But for an actual machine, it is always less than 100%.

8. Relation between efficiency (η), mechanical advantage (MA) and velocity ratio (VR)

Mechanical advantage

$$(MA) = \text{Velocity ratio } (VR) \times \text{Efficiency } (\eta)$$

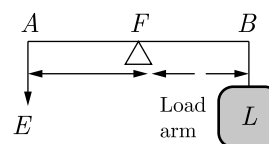
4. LEVER

A lever is a rigid, straight or bent bar which is capable of turning about a fixed turning point called fulcrum.

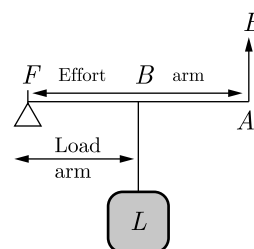
According to principle of lever

$$\text{Load} \times \text{Load arm} = \text{Effort} \times \text{Effort arm}$$

1. Depending upon the relative positions of the load, effort and fulcrum, levers are classified into three classes



Class 1 lever



Class 2 lever

For a moving object, kinetic energy, and momentum, are correlated as :

$$E_k = \frac{p^2}{2m} \text{ or } p = \sqrt{2mE_k}$$

Work-kinetic Energy Theorem

As per work-kinetic energy theorem, the work done by a force acted on the object is same as the change in kinetic energy of that object.

So, work done, $W = (E_k)_{\text{final}} - (E_k)_{\text{initial}}$

$$W = (Fs) = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

(ii) Potential Energy

The energy possessed by an object by virtue of its position or configuration is called its potential energy. Potential energy is also a scalar quantity like other forms of energy. The SI unit of potential energy is joule (J).

Potential energy is of two kinds, namely (a) gravitational potential energy, and (b) elastic potential energy.

- (a) **Gravitational potential energy :** The potential energy of an object by virtue of its position is called gravitational potential energy. The gravitational potential energy of an object at a point above the ground is the work done in raising it from the ground to that point against gravity.

Gravitational potential energy of an object of mass m situated at a height h above the ground,

$$E_p = mgh$$

Thus, $E_p \propto m$ and $E_p \propto h$

The positive and negative values of gravitational potential energy depend on the sign of height h .

- (b) **Elastic potential energy :** The potential energy of an object due to its configuration (change in shape or change in size) is called elastic potential energy. Work done against/by gravity to take an object through a certain height, h does not depend on the path selected.

Apart from mechanical energy, the energy exists in various other forms also. Few common forms of energy are thermal (heat) energy, light energy, electrical energy, chemical energy, nuclear energy, etc.

2.2 Transformation of Energy

One form of energy may be converted into another form of energy under suitable conditions. The process of changing of one form of energy into another form of energy is called the transformation of energy, e.g., when an object is fallen freely from a height, its potential energy is gradually transformed into kinetic energy. In an electric iron or heater, electrical energy is transformed into heat energy. In a thermal power station, heat (thermal) energy is obtained at the expense of chemical energy during combustion of fuel and subsequently, this heat energy is transformed into electrical energy. Few other examples may define transformation of energy.

2.3 Law of Conservation of Energy

As per law of conservation of energy, the energy can neither be created nor be destroyed but it can be converted from one form into another. Energy consumed in one form exactly reappears in some other form and the total energy of an isolated system must remain conserved during the transformation.

2.4 Power : Rate of Doing Work

Power of a person or machine or system is the rate of doing work. In other words, the rate of supply or consumption of energy is called power.

$$\begin{aligned} \text{Hence, power, } P &= \frac{\text{Work (W)}}{\text{Time (t)}} \\ &= \frac{\text{Energy supplied (E)}}{\text{Time (t)}} \end{aligned}$$

Just like work and energy, the power also has a magnitude only, i.e., it is a scalar quantity.

Unit of power

The SI unit of power is watt (W), where 1 watt (1 W) = 1 J s^{-1} . Thus, power is said to be 1 watt if the rate of doing work or rate of supply of energy is 1 joule per second.

The commercial unit of energy is kilowatt hour (kWh) though its SI unit is joule (J). Energy consumed is 1 kWh, if a machine or an appliance of 1 kilowatt power (1000 watt power) is operated for a period of 1 hour.

$$\text{Thus, Energy (kWh)} = \text{Power (kW)} \times \text{time (h)}$$

$$= P \text{ (watts)} \times t \text{ (hours)} \times 1000$$

$$1 \text{ kWh} = 1000 \text{ Wh}$$

$$= 1000 \text{ W} \times (60 \times 60) \text{ s}$$

$$= 3.6 \times 10^6 \text{ J}$$

CHAPTER 7

Work, Energy, and Simple Machines

SUMMARY

1. WORK

Work is said to be done when a force applied to an object causes it to move through a certain distance in the direction of that force. Thus, two conditions must be satisfied for mechanical work to be done as follows :

1. A force should act on the object.
2. The object must undergo some displacement along the direction of force.

1.1 Work Done by a Constant Force

When a force acts on an object, the resultant work done is equal to the product of the magnitude of force and the displacement (distance covered) in the direction of the force. Since work done has only a magnitude and no direction, hence, it is a scalar.

1.2 SI Unit of Work Done

The SI unit of work done is joule (J). Work done is said to be 1 J when, under the effect of a force of 1 N, an object moves in the direction of force through a distance of 1 m.

If an object moves at some angle to the direction of applied force, then

Work done = Displacement $\times$ Component of force along the direction of displacement

Mathematically,

work done, $W = Fs \cos \theta$

where, s = Displacement, F = Magnitude of force and θ = Angle between the directions of force and displacement

1.3 Positive and Negative Work Done

If force F and displacement (s) act in same direction, then the work will be positive and maximum, where $\theta = 0^\circ$.

So, work done, $W = Fs \cos \theta = F.s$

If force F and displacements act in mutually opposite directions, then work will be negative and minimum, where, $\theta = 180^\circ$.

So, work done, $W = Fs \cos \theta = Fs \cos 180^\circ$
 $= -Fs$

1.4 Zero Work

If force acts on an object along a direction perpendicular to the direction of displacement, then work done produced by a force is zero, where $\theta = 90^\circ$.

So, work done, $W = Fs \cos \theta = Fs \cos 90^\circ$
 $= Fs \times (0) = 0$

2. ENERGY

The capacity of doing work is called energy.

The energy possessed by an object is measured in terms of its capacity of doing work. So, the SI unit of energy is equal to SI unit of work. The SI unit of energy is joule (J). One joule of energy is the capacity of doing 1 J of work.

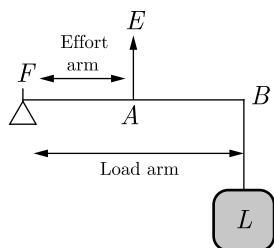
2.1 Mechanical Energy

Mechanical energy is the sum of the kinetic energy and the potential energy stored in a system. So it is of two types, namely (i) kinetic energy, and (ii) potential energy.

(i) Kinetic Energy

The energy possessed by an object by virtue of its state of motion is called kinetic energy. An object of mass m with a velocity v has kinetic energy, $E_k = \frac{1}{2}mv^2$

Thus, for a given velocity v , kinetic energy is proportional to the mass of an object, i.e., $E_k \propto m$. For an object of mass m , kinetic energy is proportional to the square of its velocity, i.e., $E_k \propto v^2$.



Class 3 lever

2. Remember *FLE* for fulcrum *F*, load *L* and effort *E* in between for Class I, II and III levers respectively

$$MA = \frac{\text{Effort arm}}{\text{Load arm}}$$

$$VR = \frac{\text{Effort arm}}{\text{Load arm}}$$

Remember :

For class I lever : Effort arm $>$, $=$ or $<$ Load arm and *MA* and *VR* may be, $>$, $=$ or $<$ 1

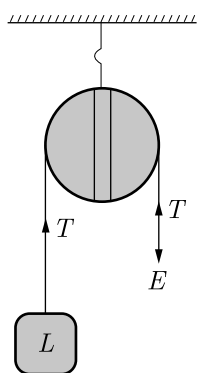
For class II lever : Effort arm $>$ Load arm and *MA* and *VR* are always greater than one, hence act as a force multiplier

For class III lever : Effort arm is always $<$ Load arm, *MA* and *VR* are always less than one, hence act as a speed multiplier

5. PULLEY

Pulley is a grooved wheel which is free to rotate on an axle.

Single fixed pulley is used to change the direction of the force applied, *i.e.* the effort can be applied in a more convenient direction. For single fixed pulley (ideal condition).



Single fixed pulley

$$MA = \frac{L}{E} = 1 \quad \{L = E\}$$

$$VR = \frac{d_E}{d_L} = 1 \quad \{d_E = d_L\}$$

$$\eta = \frac{MA}{VR} = 1 \text{ or } 100\%$$

However, if frictional forces (*f*) are not negligible,

$$L + f = T \text{ and } E = T,$$

$$MA = \frac{L}{E} = 1 - \frac{f}{E}$$

Since $VR = 1$, $\eta = \frac{MA}{VR} = 1 - \frac{f}{E}$

1. For a single movable (ideal) pulley

$$MA = VR = 2, = 1 \text{ or } 100\%$$

2. In a single movable pulley if *W* is the weight of the movable pulley, in equilibrium (as the system moves with uniform velocity.)

$$E = T \text{ and } L + w = 2T$$

$$MA = \frac{L}{E} = 2 - \frac{w}{E}$$

$$\eta = \frac{MA}{VR} = \frac{(2 - \frac{w}{E})}{2}$$

$$= 1 - \frac{w}{2E} \simeq 1 - \frac{w}{L}$$

$$\{w \ll 2E \approx L\}$$

PAUSE AND PONDER

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In the previous chapter, a weight lifter is shown holding a barbell steady in her hands. Is she doing any work on the barbell while holding it steady?

Ans :

No, she is not doing any work on the barbell in a scientific sense. Work is defined as a force causing a displacement in the direction of the force. Since the barbell is held steady and undergoes zero displacement, the work done on it is zero, despite the physical effort she feels.

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2. Is the work done by friction on the stack of coins that travels on a rough surface — positive, negative or zero?

Ans :

The work done by friction is negative. This is because the frictional force always acts in a direction directly opposite to the displacement of the sliding stack of coins.

3. When you pedal a bicycle on a flat road, your muscles supply energy. In what forms does this muscular energy appear as you ride?

Ans :

The chemical energy from your muscles is primarily converted into the mechanical energy (specifically kinetic energy) of both the moving bicycle and your body. Additionally, some of this muscular energy is inevitably converted into thermal energy due to friction in the bicycle's moving parts and air resistance, which is why your body also feels warm.

4. Two objects A and B of mass m and $4m$ have the same kinetic energy. What is the ratio of the magnitude of velocities of A and B?

Ans :

Given

Mass of A $m_A = m$

Mass of B $m_B = 4m$

Condition KE of A = KE of B

Setting Kinetic Energetic Equal

Kinetic Energy. $KE = \frac{1}{2}mv^2$

$$KE_A = KE_B$$

$$\frac{1}{2} \times m \times v_A^2 = \frac{1}{2} \times 4m \times v_B^2$$

The $1/2$ and m cancel from both sides:

$$v_A^2 = 4v_B^2$$

Taking square root on both sides:

$$v_A = 2v_B$$

Ratio of Velocities

$$\frac{v_A}{v_B} = 2 \frac{v_B}{v_B} = 2$$

$$v_A : v_B = 2 : 1$$

5. Does the kinetic energy of an object which moves with constant velocity change with its position?

Ans :

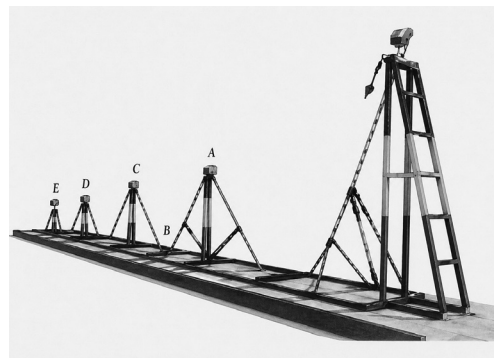
No, the kinetic energy does not change with position if the velocity is constant. Kinetic energy depends solely on the mass and the velocity of the object, so as long as neither of those changes, the kinetic energy remains constant regardless of where the object is placed.

6. Does the potential energy of an object near the surface of the Earth change if it moves with constant velocity in the horizontal direction? What if the object is gradually raised in the vertical direction?

Ans :

If an object moves horizontally, its height relative to the ground stays the same, so its gravitational potential energy does not change. However, if the object is gradually raised in the vertical direction, its height increases. This means work is done against gravity, resulting in an increase in its gravitational potential energy.

7. For the situation depicted in figure calculate the mechanical energy of the ball just before it hits the ground and show that even at this position, it is mgh .



Ans :

Just before hitting the ground, the height of the ball is zero, making its potential energy zero. To find its kinetic energy,

we use the kinematic equation $v^2 = u^2 + 2as$. Since it falls from rest ($u = 0$) over a distance h with acceleration g ,

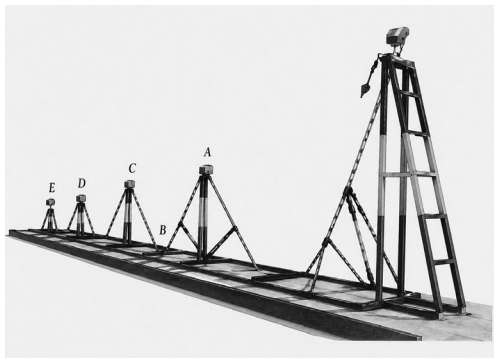
$$v^2 = 2gh.$$

Substituting this into the kinetic energy formula

$$K.E = \frac{1}{2} m(2gh) = mgh,$$

so the total mechanical energy is $0 + mgh = mgh$.

8. You may have seen an exhibit like that in Figure in a science park, where a ball is released from the highest point. Describe how the kinetic energy and potential energy change at points A, B and C. Why do subsequent points, such as C, D and E, usually have lower heights compared to the previous ones? Could it have anything to do with the energy lost due to friction?



Ans :

At point A, potential energy is high and kinetic energy is low; as it descends to B, potential energy decreases while kinetic energy increases to a maximum. As it climbs to point C, kinetic energy transforms back into potential energy, slowing the ball down. The subsequent peaks like C, D, and E must be lower because mechanical energy is not perfectly conserved in reality. As the ball rolls, some mechanical energy is continuously converted into thermal energy and sound due to friction and air resistance, leaving less total energy to achieve the original height.

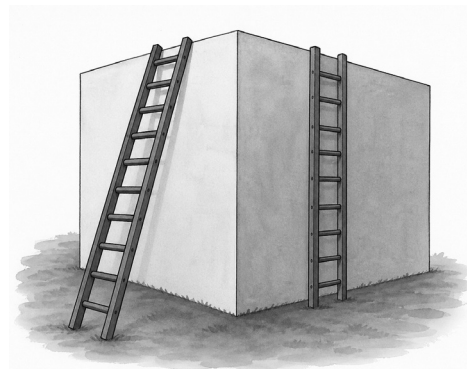
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9. Explain why roads on hills are built to wind around in gentle slopes rather than going straight up(Figure)?

Ans :

A winding road acts as a long inclined plane, which is a simple machine. By increasing the distance over which a vehicle travels to reach a certain height, the slope becomes gentler. This provides a mechanical advantage, meaning a much smaller continuous force (effort) from the engine is required to lift the heavy vehicle against gravity, compared to the massive force needed to go straight up.

10. To reach a higher floor, we find climbing an inclined ladder easier in comparison to climbing a vertical ladder as shown in the figure . Explain why ?



Ans :

An inclined ladder functions as an inclined plane, increasing the distance over which you must move to reach the same vertical height. Because work is force multiplied by distance, spreading the work over a longer distance means you need to apply less upward force at any given moment. This mechanical advantage reduces the required effort, making the climb feel much easier than hauling your entire weight straight up a vertical ladder.

11. Why is it easier to open the lid of a can by using a spoon as shown in figure ?



Ans :

The spoon acts as a lever where the edge of the can serves as the fulcrum. By holding the end of the spoon, you create a long effort arm and a very short load arm under the lid. This setup provides a significant mechanical advantage, allowing a small downward force applied by your hand to translate into a much larger upward force that easily pops the tight lid open.

12. Why do you push an object closer to scissors (fulcrum) when you want to cut an object which is hard?

Ans :

Scissors are levers, and placing a hard object closer to the pivot point (fulcrum) effectively shortens the load arm. Since mechanical advantage is calculated as the effort arm divided by the load arm, a shorter load arm increases the mechanical advantage. This means the same squeezing force from your hand results in a much greater cutting force on the object, making it easier to cut tough materials.

13. Throughout history, many designs of perpetual machines (using wheels, weights or magnets) have been proposed but none actually work. Why do all real machines eventually slow down and stop? Explain in terms of work and energy.

Ans :

Real machines eventually stop because it is impossible to eliminate friction and air resistance completely. As a machine's parts move, internal forces oppose the motion, meaning the machine must constantly do work against friction. This work converts the useful mechanical energy into non-recoverable thermal energy (heat) and sound. Without an external energy source to replace this lost mechanical energy, the machine will run out of kinetic energy and stop.

NCERT EXERCISE

1. State whether True or False.
- Work is said to be done when a force is applied, even if the object does not move.
 - Lifting a bucket vertically upward results in positive work done on the bucket.
 - The SI unit for both work and energy is joule (J).
 - A motionless stretched rubber band has kinetic energy.
 - Energy can change from one form to another.

Ans :

- False, According to the scientific definition, work done is zero if there is no displacement, regardless of the force applied.
- True, The force applied to lift the bucket and the resulting displacement are both in the same upward direction.

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- True, Energy is the capacity to do work, and the work-energy theorem connects the two, so they share the same SI unit.
- False, A motionless stretched rubber band possesses potential energy due to its deformed shape, while kinetic energy is the energy of motion.
- True, Energy can transform between forms, such as potential energy converting into kinetic energy when an object falls.

2. Fill in the blanks.

- Work done = _____ $\times$ _____ (in the direction of force).
- 1 joule of work is done when a force of _____ newton displaces an object by 1 metre in the direction of the force.
- The expression for kinetic energy of a body of mass m and velocity v is _____.
- The potential energy of an object of mass m at a small height h from the Earth's surface is _____.
- Power is defined as the _____ at which work is done.

Ans :

- force, displacement
- 1
- $\frac{1}{2}mv^2$
- mgh
- rate

3. When a ball thrown upwards reaches its highest point, tick which of the following statement(s) are correct?

- The force acting on the ball is zero.
- The acceleration of the ball is zero.
- Its kinetic energy is zero.
- Its potential energy is maximum.

Ans :

- Incorrect. The gravitational force continues to pull downwards on the ball even at the highest point.
- Incorrect. The acceleration due to gravity remains constant and points downwards at all times during the flight.
- Correct. At the highest point, the ball momentarily comes to a stop (velocity becomes zero), meaning its kinetic energy is zero.
- Correct. As the ball reaches its maximum height, the value of height (h) is at its greatest, making gravitational potential energy (mgh) maximum.

4. For each of the following situations, identify the energy transformation that takes place: (i) a truck moving uphill, (ii) unwinding of a watch spring, (iii) photosynthesis in green leaves, (iv) water flowing from a dam, (v) burning of a matchstick, (vi) explosion of a fire cracker, (vii) speaking into a microphone, (viii) a glowing electric bulb, and (ix) a solar panel.

Ans :

- (i) Kinetic energy (and chemical energy from fuel) transforms into gravitational potential energy as the truck gains height.
 - (ii) Elastic potential energy stored in the wound spring transforms into mechanical (kinetic) energy to move the watch hands.
 - (iii) Light energy from the sun transforms into chemical energy stored in the plant's food bonds.
 - (iv) Gravitational potential energy of the stored water transforms into kinetic energy as it flows downward.
 - (v) Chemical energy stored in the match head transforms into thermal (heat) energy and light energy.
 - (vi) Chemical energy stored in the explosive powder transforms into sound energy, light energy, and thermal energy.
 - (vii) Sound energy from the voice transforms into electrical energy as signals in the microphone wire.
 - (viii) Electrical energy transforms into light energy and thermal (heat) energy.
 - (ix) Light energy from the sun transforms into electrical energy.
5. A student is slowly lifted straight up in an elevator from the ground level to the top floor of a building. Later, the same student climbs the staircase, all the way to the top. Given that the height of the building is $h = 72.5$ m, acceleration due to gravity is $g = 10 \text{ ms}^{-2}$, and student's mass is $m = 50$ kg.
- i. Find the gain in the potential energy if the student is lifted straight up to the top.
 - ii. Find the gain in the potential energy when the student climbs the stairs to the same top.
 - iii. What do you conclude about the dependence of the potential energy on the path taken?

Ans :

- i. The gain in potential energy when the student is lifted straight up to the top on the elevator

is given by $\Delta PE = mgh$. Substituting the values,

$$\begin{aligned}\Delta PE &= 50 \times 10 \times 72.5 \\ &= 36,250 \text{ J} = 3.625 \times 10^4 \text{ J}.\end{aligned}$$

- ii. When the student climbs the staircase to the same top floor, the vertical height gained remains the same, $h = 72.5$ m. Therefore, using the same formula,

$$\begin{aligned}\Delta PE &= mgh = 50 \times 10 \times 72.5 \\ &= 36,250 \text{ J} = 3.625 \times 10^4 \text{ J}.\end{aligned}$$

- iii. The gain in potential energy is identical in both cases, even though the paths taken- a direct vertical lift in the elevator and a winding staircase- are entirely different. This leads to the conclusion that gravitational potential energy depends only on the vertical height gained, and not on the path followed to reach that height. Gravity is therefore a conservative force.

6. A crane lifts a mass m to the 10th floor of a building in a certain time. It then raises the same mass to the 20th floor of the same building in double the time. How much more energy and power are required? Assume that the height of all floors is equal.

Ans :

Let the height of each floor be d . The crane lifts mass m to the 10th floor in time t , and to the 20th floor in $2t$.

Therefore $h_1 = 10d$, t and $h_2 = 20d$, $t_2 = 2t$
Energy required to reach the 10th floor:

$$\begin{aligned}E_1 &= mgh_1 = mg \times 10d \\ &= 10mgd\end{aligned}$$

Energy required to reach the 20th floor:

$$\begin{aligned}E_2 &= mgh_2 = mg \times 20d \\ &= 20mgd\end{aligned}$$

Ratio of energies:

$$E_2/E_1 = 20mgd/10mgd = 2$$

The crane required twice the energy to lift the mass to the 20th floor.

Power required to reach the 10th floor:

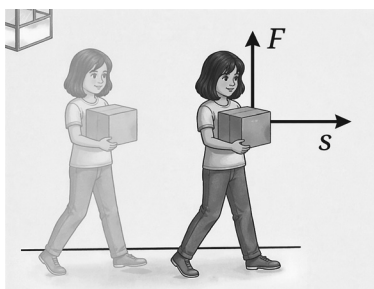
$$P_1 = E_1/t = 10mgd/t$$

Power required to reach the 20th floor:

$$P_2 = E_2/t_2 = 20mgd/2t = 10mgd/t$$

When a person pushes a rigid wall, they apply a substantial muscular force, but the wall does not move. Because the scientific definition of work strictly requires displacement in the direction of the applied force, the work done on the wall is exactly zero. The person feels tired merely due to internal muscle energy expenditure.

3. A girl walks horizontally at a constant speed while carrying a heavy box, as represented by the arrows for force (F) and displacement (s). What is the mathematical work done by the upward force applied on the box?



- (A) Maximum positive work, as the heavy box requires significant effort to hold.
 (B) Negative work, as the gravitational pull acts in the downward direction.
 (C) Zero work, as the applied force and the displacement are perpendicular.
 (D) Positive work, as she successfully moves the box in the forward direction.

Ans : (C)

Work done by a force evaluates to zero when the applied force acts perpendicularly to the direction of displacement. Here, the girl exerts an upward force to balance the weight of the box, but the displacement is strictly horizontal. Since these two vectors form a ninety-degree angle, the resulting work done by the upward force is zero.

4. During a fast-paced football match, a goalkeeper stops a fiercely kicked ball by applying force using their hands. What type of work is done by the goalkeeper on the football?
- (A) Positive work
 (B) Negative work
 (C) Zero work
 (D) Infinite work

Ans : (B)

Negative work occurs when the applied force and the displacement of the object are in directly opposite directions. When a goalkeeper catches

a moving football, they apply a braking force against the ball's motion. The ball displaces slightly backwards, opposite to the stopping force, thus resulting in negative work being done by the goalkeeper's hands.

5. Consider the following statements regarding the concept of work in physics:
1. Pushing a wheelchair forward on a flat road constitutes positive work.
 2. The SI unit of work done is the newton.
 3. Work done is zero if displacement is zero, regardless of applied force.

Select the correct combination of statements:

- (A) 1 and 2 only
 (B) 2 and 3 only
 (C) 1 and 3 only
 (D) 1, 2, and 3

Ans : (C)

The concept of work firmly establishes that force and displacement must have a component in the same line. If displacement is zero, work is inherently zero. Pushing a wheelchair forward is a classic example of positive work because the applied muscular force aligns exactly with the forward displacement of the wheelchair on the flat ground.

6. **Assertion (A):** When a person slowly carries a heavy box while walking horizontally at a constant speed, the work done by the upward carrying force is strictly zero.

Reason (R): The upward force applied on the box is entirely perpendicular to the horizontal displacement of the person walking.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

Work done is precisely the product of force and displacement along the direction of force. When an object moves horizontally while gravity acts vertically downwards, the angle between the gravitational force and displacement is exactly perpendicular. Consequently, there is absolutely no displacement in the direction of gravity, making the work done by gravity zero.

Ans :

- (i) During upward motion, the displacement is upwards but the gravitational force pulls downwards, resulting in negative work. During downward motion, both the displacement and the gravitational force are directed downwards, resulting in positive work.
- (ii) Using the work-energy theorem, the total work done on the ball equals the change in its kinetic energy. At the maximum height, the ball momentarily comes to rest, so its final kinetic energy is zero.

Initial kinetic energy:

$$\begin{aligned} \text{KE} &= \frac{1}{2} mu^2 \\ &= \frac{1}{2} \times 2 \times (20)^2 = 400 \text{ J} \end{aligned}$$

Work done by gravity (upward journey):

$$W_{\text{gravity}} = -mgh = -2 \times 10 \times 19.4 = -388 \text{ J}$$

Applying the work-energy theorem for the upward journey:

$$\begin{aligned} W_{\text{gravity}} + W_{\text{air}} &= \Delta \text{KE} = \text{KE}_{\text{final}} - \text{KE}_{\text{initial}} \\ &= 0 - 400 = -400 \text{ J} \end{aligned}$$

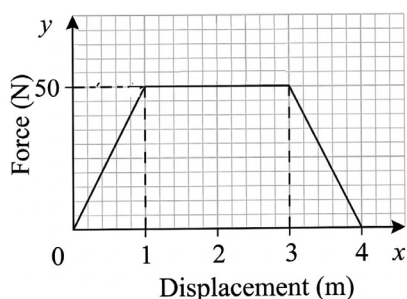
$$\begin{aligned} \text{Therefore, } W_{\text{air}} &= -400 - W_{\text{gravity}} \\ &= -400 - (-388) \end{aligned}$$

$$W_{\text{air}} = -400 + 388 = -12 \text{ J}$$

The work done by air resistance is -12 J. The negative sign confirms that air resistance always opposes the motion of the ball, removing energy from it throughout the upward journey.

11. A 10.0 kg block is moving on horizontal floor with negligible friction. As shown in the figure a variable force is applied on the block in its direction of motion from its position at 0 m till 4 m. If the block had a kinetic energy of 180 J when it was at 0 m, find the block's speed
- at 0 m, and
 - at 4 m.

Does the block have negative acceleration in any portion of its motion?



Ans :

Use the work-energy theorem:

$$\text{Work done} = \Delta \text{KE}$$

From the graph (Force vs displacement):

Work done from 0 m to 4 m

Break into parts:

- (i) 0 → 1 m (triangle)

$$W_1 = \frac{1}{2} \times 1 \times 50 = 25 \text{ J}$$

- (ii) 1 → 3 m (rectangle)

$$W_2 = 2 \times 50 = 100 \text{ J}$$

- (iii) 3 → 4 m (triangle)

$$W_3 = \frac{1}{2} \times 1 \times 50 = 25 \text{ J}$$

Total work:

$$\begin{aligned} W &= 25 + 100 + 25 \\ &= 150 \text{ J} \end{aligned}$$

Given:

Initial KE at 0 m = 180 J

Final KE at 4 m:

$$\text{KE} = 180 + 150 = 330 \text{ J}$$

Speeds

- (i) At 0 m:

$$180 = \frac{1}{2} \times 10 \times v^2$$

$$v = \sqrt{36} = 6 \text{ m/s}$$

- (ii) At 4 m:

$$330 = \frac{1}{2} \times 10 \times v^2$$

$$v = \sqrt{66} \approx 8.1 \text{ m/s}$$

Negative acceleration?

Acceleration depends on force direction.

Here, force is always positive (forward direction), though decreasing later.

So, acceleration is never negative (only decreasing but still positive).

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12. The gravitational attraction on the surface of the Moon (lunar surface) is about 1/6th of that on the surface of the Earth. An astronaut can throw a ball up to a height of 8 m from the surface of the Earth. How far up will the ball thrown with the same upward velocity travel from the surface of the Moon?

Ratio of Powers:

$$P_1/P_3 = (10 \text{ mgd/t}) / (10 \text{ mgd/t}) = 1$$

The power required is the same in both cases.

7. Which factors determine the energy required to raise a flag from the ground to the top of a tall flagpole using a pulley? Does raising the flag slowly or quickly change the amount of work done? If the speed at which the flag is raised is doubled, how does the power requirement change? Explain your answers.

Ans :

The energy required to raise the flag is determined by its gravitational potential energy (mgh), which depends on the mass of the flag, the acceleration due to gravity, and the height of the flagpole. Raising the flag quickly or slowly does not change the amount of work done because work only depends on the force applied against gravity and the displacement, which remain constant. However, if the speed is doubled, the time taken to raise the flag is halved. Since power is the rate of doing work (Work/time), halving the time doubles the power requirement.

8. A man of mass 60 kg rides a scooter of mass 100 kg. He accelerates the scooter to a velocity v . The next day, his son with a mass of 40 kg joins him as a passenger. If the scooter reaches the same speed on both days in the same time interval, what is the ratio of the fuel of the tank used on the two days? Assume that the energy transfer to the scooter happens entirely due to fuel, and no other losses occur due to air resistance and friction.

Ans :

Given,

Mass of man, $m_1 = 60 \text{ kg}$

Mass of scooter, $m_s = 100 \text{ kg}$,

Mass of son, $m_2 = 40 \text{ kg}$.

The scooter reaches the same final velocity v from rest in the same time interval on both days. Since no cases due to friction or air resistance occur, all fuel energy goes into the kinetic energy of the system.

Total mass on Day (1 man + scooter):

$$M_1 = 60 + 100 = 160 \text{ kg}$$

Total mass on Day 2 (man + son + scooter)''

$$M_2 = 60 + 40 + 100 = 200 \text{ kg}$$

Kinetic Energy on Day 1:

$$KE_1 = \frac{1}{2} M_1 v^2 = \frac{1}{2} \times 160 \times v^2 = 80v^2$$

Kinetic energy on Day 2:

$$KE_2 = \frac{1}{2} M_2 v^2 = \frac{1}{2} \times 200 \times v^2 = 100v^2$$

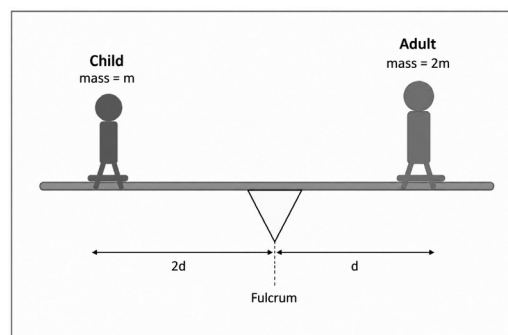
Ratio of fuel used (Day 1 : Day 2):

Since all fuel converts to kinetic energy, the fuel used is directly proportional to the kinetic energy gained. Therefore,

$$\begin{aligned} \text{Fuel}_1 / \text{Fuel}_2 &= \frac{KE_1}{KE_2} = \frac{80v^2}{100v^2} \\ &= \frac{80}{100} = \frac{4}{5} = 4 : 5 \end{aligned}$$

9. On a seesaw with sliding seats, a child is sitting on one side and an adult on the other side. The adult weighs twice that of the child. The seesaw however is balanced. Draw a figure which depicts this situation showing the distances from the fulcrum where the child and the adult are seated.

Ans :



The diagram shows the key idea clearly. For the seesaw to be balanced, the moments (torques) on both sides must be equal. Since the adult has twice the mass, the child must sit at twice the distance from the fulcrum to compensate:

$$\text{Moment due to child} = m \times 2d = 2md$$

$$\text{Moment due to adult} = 2m \times d = 2md$$

Both moments are equal, so the seesaw remains perfectly balanced — this is the principle of moments (or law of the lever).

10. A ball of mass 2 kg is thrown up with a velocity of 20 ms^{-1} .
- Identify the sign of the work done by gravity on the ball during its upward motion and its downward motion.
 - If the ball reaches a height of 19.4 m, how much work was done by air resistance (assume $g = 10 \text{ m s}^{-2}$).

Velocity at P :

$$\begin{aligned}\text{KE at P} &= \text{Total Energy} - \text{PE at P} \\ &= 30 - 20 = 10 \text{ J}\end{aligned}$$

Since $\text{KE} = \frac{1}{2}mv^2$

$$10 = \frac{1}{2} \times 0.5 \times v^2$$

$$10 = 0.25 \times v^2$$

$$v^2 = 40$$

$$v \text{ at P} = 2\sqrt{10} \text{ ms}^{-1}$$

Velocity at Q :

At Q, all the mechanical energy exists as potential Energy and Kinetic Energy is zero.

$$v \text{ at Q} = 0 \text{ ms}^{-1}$$

Velocity at R :

$$\begin{aligned}\text{KE at R} &= \text{Total Energy} - \text{PE at R} \\ &= 30 - 40 = -10 \text{ J}\end{aligned}$$

Since Kinetic Energy can never be negative, the ball does not have sufficient energy to reach point R. The total mechanical energy (30 J) is less than the potential energy required at R (40 J).

Therefore, the ball cannot reach point R.

15. A coconut of mass 1.5 kg falls from the top of a coconut tree onto the wet sand on a beach. The height of the tree is 10 m. On impact, the coconut comes to rest by making a depression in the sand.
- Calculate the velocity of the coconut just before it hits the sand.
 - Assume that the average resistive force of sand is 3000 N and all of the coconut's energy is used to create the depression in the sand. Calculate the depth of the depression the coconut makes in the sand. Assume $g = 10 \text{ m s}^{-2}$.

Ans :

- The potential energy at the top = mgh
 $= 1.5 \text{ kg} \times 10 \text{ m/s}^2 \times 10 \text{ m}$
 $= 150 \text{ J}.$

By conservation of energy, this entirely converts to kinetic energy just before impact.

So, $\frac{1}{2}mv^2 = 150 \text{ J}.$

Therefore,

$$\begin{aligned}\frac{1}{2} \times 1.5 \times v^2 &= 150, \\ 0.75 v^2 &= 150, \\ v^2 &= 200.\end{aligned}$$

The velocity is the square root of 200, which is approximately 14.14 m/s.

- The kinetic energy of the coconut before impact (150 J) is used to do work against the resistive force of the sand.

Work done = Force $\times$ displacement (depth).

$$3000 \text{ N} \times \text{depth} = 150 \text{ J}.$$

$$150 / 3000 = 0.05 \text{ m}.$$

The depth of the depression is 0.05 m (or 5 cm).

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OBJECTIVE QUESTIONS

- What is the fundamental scientific requirement for mechanical work to be done on an object by an applied force?
 - The object must be stationary while the heavy force is applied.
 - The object must gain excessive mass during the force application.
 - The object must be displaced along the direction of the applied force.
 - The object must be displaced completely perpendicular to the applied force.

Ans : (C)

Work is scientifically defined as the product of the force applied to an object and its displacement in the direction of that force. If an object does not move despite heavy force, the displacement is zero, resulting in zero work. This fundamental physics concept clearly differentiates everyday effort from actual mechanical work performed on physical objects.

- A student applies a massive push force against a solid, unmoving brick wall for several minutes until physically exhausted. How much scientific work is done on the wall?
 - Positive work, because significant muscular effort was continuously exerted.
 - Negative work, because the wall pushed back with an equal opposite force.
 - Infinite work, because the wall is highly resistant to any motion.
 - Zero work, because the wall did not physically displace from its position.

Ans : (D)

Ans :

Given gravitational acceleration on Earth $g_E = g$ on the Moon $g_M = g/6$, height reached on Earth $h_E = 8$ m, and the ball is thrown the same initial velocity U on both surfaces.

At maximum height the ball comes to rest ($v=0$),

Using $v^2 = u^2 - 2gh$ with $v = 0$, $u^2 = 2gh$

Since u is same on both surfaces, the product gh remains constant, giving:

$$g_E \times h_E = g_M \times h_M$$

$$\text{On Earth } u^2 = 2 \times g \times 8 = 16g \quad (1)$$

$$\text{On the Moon } u^2 = 2 \times (g/6) \times h_M \quad (2)$$

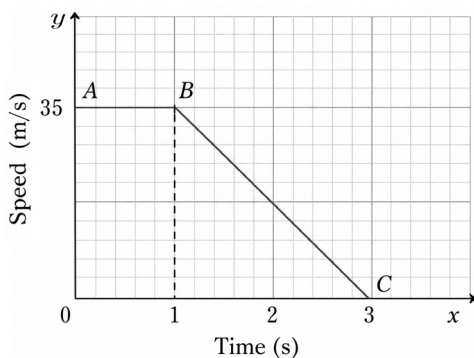
Equating (1) and (2)

$$16g = 2 \times (g/6) \times h_M$$

$$h_M = (16g \times 6) / (2g)$$

$$h_M = 48\text{m}$$

13. A 1000 kg car is moving along a road at a constant speed. Suddenly, the driver notices some obstruction ahead and applies the brakes to come to a complete stop. The graphical representation of motion of the car starting from the instant the driver spots the traffic ahead is shown in figure.



- Describe how the car moves between positions A and B.
- Calculate the kinetic energy of the car at A.
- State the work done by the brakes in bringing the car to a halt between B and C.
- What does the kinetic energy of the car transform into?

Ans :

- Between positions A and B, the car moves with a constant, uniform speed of 35 m/s. This horizontal line on the graph represents the driver's reaction time before the brakes are actually applied.

- At position A,

the speed = 35 m/s and

the mass = 1000 kg.

Kinetic energy = $\frac{1}{2}mv^2$

$$= \frac{1}{2} \times 1000 \times (35)^2$$

$$= 500 \times 1225 = 612,500 \text{ J.}$$

- By the work-energy theorem, the work done by the brakes equals the change in kinetic energy. Since the car stops at C, its final kinetic energy is 0.

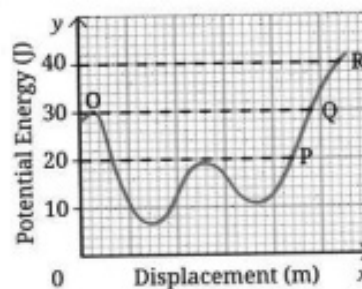
Work done = Final KE - Initial KE

$$= 0 - 612,500 \text{ J} = -612,500 \text{ J.}$$

The negative sign shows work is done opposite to the motion.

- The kinetic energy of the car transforms primarily into thermal energy (heat) and sound energy due to the friction between the brake pads and wheels, and between the tires and the road surface.

14. The potential energy-displacement graph of a 0.5 kg ball moving along a frictionless track is shown in figure. At O, the velocity of the ball is 0 ms^{-1} and potential energy is 30 J. Calculate the velocity of the ball at P, Q and R.



Ans :

Given,

Mass of ball (m) = 0.5 kg

Velocity at Q = 0 ms^{-1}

Potential Energy at Q = 30 J

From graph : PE at P = 20 J PE at R = 40 J

Since the track is frictionless, Total Mechanical Energy remains constant throughout the motion.

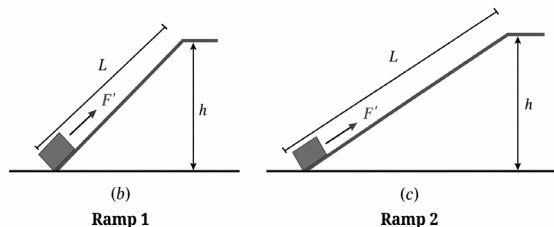
At point Q.

velocity = 0, therefore KE at Q = 0

Total Mechanical Energy

$$= \text{KE} + \text{PE} = 0 + 30 = 30 \text{ J}$$

7. Two identical heavy loads are pushed up two different inclined planes to the identical vertical height h . How does the mechanical advantage of Ramp 2 mathematically compare to the mechanical advantage of Ramp 1?



- (A) Ramp 2 has a greater mechanical advantage because the effort force required is smaller.
 (B) Ramp 2 has a smaller mechanical advantage because the total distance travelled is greater.
 (C) Both ramps have the same mechanical advantage since the vertical height reached is identical.
 (D) Both ramps have a mechanical advantage of exactly one since the load mass is unchanged.

Ans : (A)

The mechanical advantage of an inclined plane is defined as the ratio of its length to its vertical height. Since Ramp 2 possesses a greater length for the identical height, its mechanical advantage is proportionally larger. Consequently, a smaller effort force is required to move the identical load up the longer incline compared to Ramp 1.

8. How is the total work done by a precisely constant force graphically determined from a standard mathematical force-displacement plot?
- (A) By calculating the simple slope of the plotted force line.
 (B) By finding the geometric area directly under the force-displacement graph.
 (C) By multiplying the graph's vertical intercept precisely by its horizontal intercept.
 (D) By simply taking the exact square root of the force values.

Ans : (B)

The force-displacement graph visually represents work done. For a constant force, the graph is a horizontal straight line. The area bounded by this line, the x-axis, and the initial and final position verticals forms a rectangle. Calculating this precise rectangular area mathematically directly yields the total work done on the object by the applied force.

9. Match the various physical scenarios in List-I precisely with their corresponding dominant energy transformations described in List-II.

	List-I (Scenario)		List-II (Energy Transformation)
P.	A glowing electric light bulb	1.	Chemical energy strictly into mechanical energy
Q.	A ringing school bell	2.	Light energy strictly into electrical energy
R.	An operating solar cell panel	3.	Electrical energy strictly into light energy
S.	Food fueling human muscle motion	4.	Mechanical energy strictly into sound energy

Select the correct matching sequence:

- (A) P-3, Q-4, R-2, S-1
 (B) P-2, Q-4, R-3, S-1
 (C) P-3, Q-1, R-2, S-4
 (D) P-4, Q-3, R-1, S-2

Ans : (A)

Different scenarios exhibit various forms of energy transformation. A glowing electric bulb fundamentally converts electrical energy into light energy. Photosynthesis in green leaves involves converting solar light energy into stored chemical energy. A ringing bell transforms mechanical energy into sound energy, demonstrating how energy changes forms based on the device or natural biological process involved.

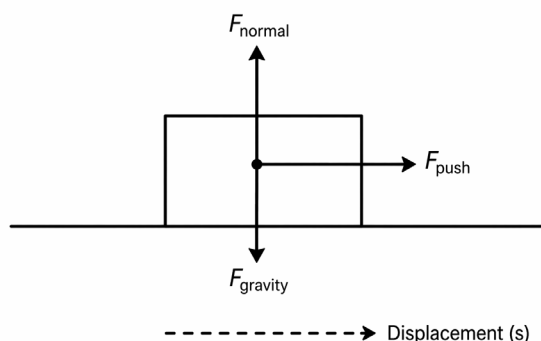
According to the work-energy theorem, the total mechanical work effectively done on a given physical object is strictly equal to what physical parameter?

- (A) The exact change in its internal thermal temperature.
 (B) The precise change in its structural mass.
 (C) The total change in its kinetic or potential energy.
 (D) The strict inverse of its continuous moving velocity.

Ans : (C)

The work-energy theorem fundamentally states that the net work done on an object by all applied forces exactly equals the change in its energy. Whether a force accelerates a stationary car or lifts a heavy pot against gravity, the total mechanical

18. Based on the diagram depicting the forces acting on a moving block, which force or combination of forces performs zero work on the block?



- (A) F_{push} only
 (B) F_{gravity} and F_{normal}
 (C) F_{push} and F_{gravity}
 (D) F_{normal} only

Ans : (B)

Work is calculated as the product of force and displacement in the direction of the force. If a force acts perpendicular to the displacement, it does zero work. Here, both F_{gravity} and F_{normal} act vertically, while displacement is horizontal (a 90-degree angle). Therefore, both these forces do zero work, whereas F_{push} does positive work.

19. **Assertion (A):** The strictly calculated kinetic energy of a constantly moving physical object can absolutely never physically be a negative numerical value.

Reason (R): The standard kinetic energy formula distinctly squares the object's moving velocity, ensuring the final resulting mathematical calculation strictly yields entirely positive numerical values.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

Both the assertion and the reason are fundamentally true statements, and the reason provides the precise mathematical explanation for the assertion. Since mass is an inherently positive physical quantity and the square of any

real velocity is always positive, their product in the kinetic energy formula guarantees that kinetic energy can never be negatively valued.

20. Four different water pumps lift specific loads of water to designated heights. Based on the operational data recorded, which pump delivers the highest power? (Assume acceleration due to gravity, $g = 10 \text{ m/s}^2$)

Pump Machine	Mass of Water Lifted (kg)	Height Raised (m)	Time Taken (s)
Machine W	50	10	50
Machine X	100	5	25
Machine Y	20	20	10
Machine Z	40	10	40

- (A) Machine W
 (B) Machine X
 (C) Machine Y
 (D) Machine Z

Ans : (C)

Power is defined as the exact rate of doing work, calculated by dividing the total work done by the time taken. Machine Y successfully completes 4000 J of work in merely 10 seconds, yielding a power of 400 W. This is significantly greater than the maximum power outputs of machines W, X, and Z.

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21. When a trained archer smoothly pulls backward on a traditional archery bowstring, what specific physical form of energy strictly accumulates directly inside the effectively deformed wooden bow?

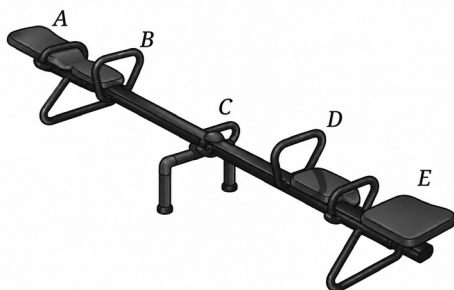
- (A) Maximum gravitational potential energy
 (B) Substantial elastic potential energy
 (C) Direct translational kinetic energy
 (D) Immediate nuclear potential energy

Ans : (B)

Elastic potential energy is accumulated strictly when an object undergoes a temporary physical deformation, such as stretching, compressing, or bending. When an archer pulls a bowstring, muscular work is done against the bow's internal elastic forces. This applied mechanical work is effectively stored within the fundamentally deformed bow as highly usable elastic potential energy.

increase. Therefore, the new kinetic energy will mathematically be exactly four times greater than its original initial value.

15. A lever acts as a seesaw pivoted at fulcrum C, with seating positions marked A, B, D, and E. The distances AC and EC equal 2 metres, while BC and DC equal 1 metre. A child weighing 300 N sits at seat A. Where must a heavier child weighing 600 N sit to balance the lever horizontally?



- (A) At seat E, which is located exactly 2 metres from the central fulcrum.
 (B) At seat D, which is located exactly 1 metre from the central fulcrum.
 (C) At seat B, which is located exactly 1 metre from the central fulcrum.
 (D) The seesaw cannot be balanced as the second child is significantly heavier.

Ans : (B)

For a lever to balance perfectly, the product of the load and load arm must equal the product of the effort and effort arm. The moment created by the first child is 600 Newton-metres. To counteract and balance this, the 600-Newton child must sit at a distance of one metre on the opposite side, matching seat D.

16. Read the following theoretical physical statements strictly regarding the fundamental scientific concept of kinetic energy:

1. Kinetic energy can logically be a negative numerical value.
2. The standard SI measuring unit for kinetic energy is the strictly identical joule used for mechanical work.
3. An object completely at rest definitely possesses zero kinetic energy.
4. Kinetic energy precisely depends entirely on both object mass and object speed.

Select the exact correct combination of perfectly valid statements:

- (A) 1, 2, and 3 only
 (B) 2, 3, and 4 only
 (C) 1, 3, and 4 only
 (D) 1, 2, 3, and 4

Ans : (B)

Kinetic energy is a scalar quantity depending entirely on mass and the square of velocity, possessing no directional vector. The SI unit for measuring kinetic energy remains the joule, exactly like work. An object at rest possesses zero velocity, hence zero kinetic energy. Unlike velocity, kinetic energy strictly remains positive or zero under all circumstances.

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17. Four different objects undergo a specific displacement when a constant force is applied to them. Based on the provided data, which object experiences negative work done by the applied force?

Object	Force Applied (N)	Displacement (m)	Direction of Force (relative to displacement)
Object A	10	5.0	Same direction as displacement
Object B	15	0.0	Same direction as displacement
Object C	20	2.0	Opposite direction to displacement
Object D	5	10.0	Perpendicular to displacement

- (A) Object A
 (B) Object B
 (C) Object C
 (D) Object D

Ans : (C)

Work is accurately defined as the product of force and displacement. When force acts in the direction directly opposite to displacement, the work done is negative. Object C experiences a force opposing its ongoing motion, resulting in negative work. Objects A, B, and D experience positive, zero, and zero work respectively.

4. Total unresisted mechanical energy fundamentally always perfectly mathematically absolutely strictly always stays identically perfectly constant everywhere exactly.

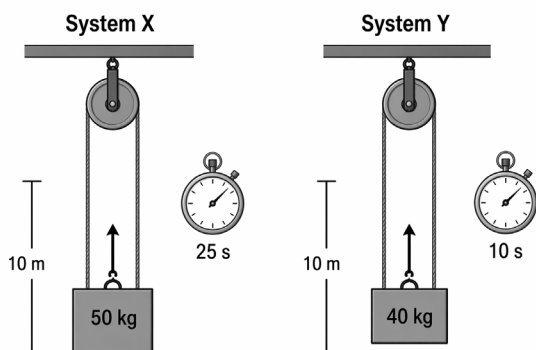
Select the perfectly accurate combination of perfectly valid physical statements:

- (A) 1 and 3 only
(B) 2 and 3 only
(C) 1, 2, and 4 only
(D) 2, 3, and 4 only

Ans : (B)

Mechanical energy conservation strictly holds true when only conservative forces, like gravity, act upon the specific system. In real-world practical scenarios, mechanical energy often slowly dissipates due to non-conservative forces like friction or air resistance. The sum of kinetic and potential energies forms mechanical energy, which precisely remains constant during ideal, frictionless, unresisted free falls.

34. Assuming acceleration due to gravity is 10 m/s^2 , how does the power exerted by System X compare to the power exerted by System Y?



- (A) System X exerts twice the power of System Y.
(B) System Y exerts twice the power of System X.
(C) Both systems exert the exact same power.
(D) System X exerts four times the power of System Y.

Ans : (B)

Power is the rate of doing work, calculated as

$$P = mgh/t.$$

For System X, power is

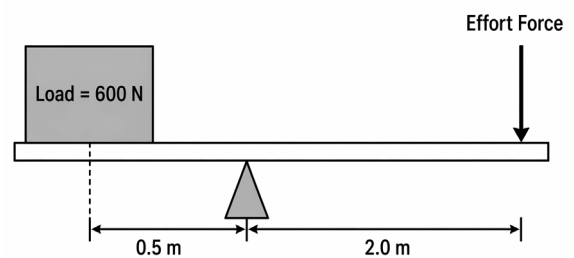
$$(50 \times 10 \times 10)/25 = 200 \text{ W}.$$

For System Y, power is

$$(40 \times 10 \times 10)/10 = 400 \text{ W}.$$

Therefore, System Y operates at 400 W, which is exactly twice the 200 W power of System X.

35. The lever shown is in a state of perfect horizontal balance. What is the magnitude of the Effort Force required, and what is the mechanical advantage of this lever?



- (A) Effort Force = 150 N, Mechanical Advantage = 4
(B) Effort Force = 300 N, Mechanical Advantage = 2
(C) Effort Force = 2400 N, Mechanical Advantage = 0.25
(D) Effort Force = 150 N, Mechanical Advantage = 0.25

Ans : (A)

For a balanced lever,

$$\text{Load} \times \text{Load Arm} = \text{Effort} \times \text{Effort Arm}.$$

Hence, $600 \text{ N} \times 0.5 \text{ m} = \text{Effort} \times 2.0 \text{ m}$, yielding an Effort of 150 N. Mechanical advantage is the ratio of Load to Effort ($600 / 150$) or Effort Arm to Load Arm ($2.0 / 0.5$), both of which calculate to exactly 4.

36. **Assertion (A):** A heavy physical object dynamically dropped freely entirely straight downwards from immense height firmly precisely rigidly maintains exactly constant perfect total unchanging mechanical energy throughout completely.

Reason (R): Strictly as the heavy object steadily steadily falls downwards, its entirely continually decreasing exact potential energy perfectly mathematically exactly perfectly uniquely exactly entirely instantaneously absolutely converts exactly into pure kinetic energy.

22. A worker needs to push a heavy wooden crate up into a moving truck. Four different smooth inclined planes are available. Assuming zero friction, which ramp requires the least effort force to lift the load?

Ramp Option	Height of Ramp (m)	Length of Ramp (m)
Ramp K	2.0	6.0
Ramp L	3.0	12.0
Ramp M	1.5	4.5
Ramp N	4.0	10.0

- (A) Ramp K
(B) Ramp L
(C) Ramp M
(D) Ramp N

Ans : (B)

A simple machine's mechanical advantage is essentially the ratio of load to effort. For inclined planes, it equals the ratio of length to height. Ramp L possesses the highest mechanical advantage ratio of four, meaning it provides the greatest force multiplication. Consequently, it consistently requires the least effort to safely move a specific heavy load.

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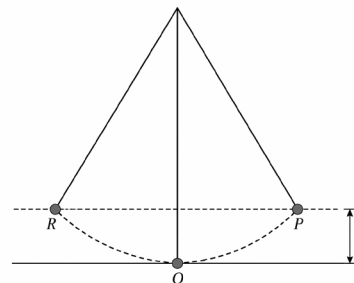
23. Which precise formula mathematically calculates the exact total gravitational potential energy strictly gained by an object of mass m carefully lifted perfectly vertically to a definite height h from the ground?

- (A) $U = \frac{1}{2}mh^2$
(B) $U = mgh$
(C) $U = \frac{m}{h}$
(D) $U = mg^2h$

Ans : (B)

The gravitational potential energy of an object is strictly defined relative to a reference level, usually the ground. To lift an object of mass m to height h , a minimum upward force equal to its weight mg is required. The mechanical work done against gravity is mgh , which precisely becomes the stored gravitational potential energy.

24. An oscillating simple pendulum moves between extreme points P and R, passing through the lowest point Q. Assuming no air resistance, which statement accurately describes the mechanical energy of the pendulum bob during its motion?



- (A) The kinetic energy is maximum at P and R, while potential energy is maximum at Q.
(B) The total mechanical energy continually decreases as the bob moves from P to Q.
(C) The potential energy at P transforms entirely into kinetic energy when reaching Q.
(D) The mechanical energy is highest at P and lowest at Q due to gravitational pull.

Ans : (C)

In the absence of external resistive forces, the total mechanical energy of a pendulum remains conserved. At the extreme point P, the bob possesses maximum potential energy and zero kinetic energy. As it descends to the lowest point Q, this potential energy converts entirely into kinetic energy, maintaining a constant total mechanical energy throughout the motion.

25. A physically heavy metal block possessing exactly 10 kg of mass is slowly lifted directly upwards exactly 5m above the floor. Strictly assuming $g = 10m/s^2$, what is its newly acquired gravitational potential energy?

- (A) 50J
(B) 150J
(C) 500J
(D) 250J

Ans : (C)

Gravitational potential energy strictly depends on mass, gravitational acceleration, and vertical height. By applying the standard physics formula for potential energy ($U = mgh$), we multiply the mass of 10 kg, gravity of $10m/s^2$, and the vertical height of 5 m. This specific mathematical

multiplication yields a total stored potential energy of exactly 500 joules.

26. A transportation company is testing four different prototype vehicles. Based on the mass and final velocity recorded in the testing logs, which vehicle currently possesses the maximum kinetic energy?

Vehicle Prototype	Mass (kg)	Velocity (m/s)
Vehicle P	1000	10
Vehicle Q	500	20
Vehicle R	2000	5
Vehicle S	100	30

- (A) Vehicle P
(B) Vehicle Q
(C) Vehicle R
(D) Vehicle S

Ans : (B)

Kinetic energy depends directly on an object's mass and the square of its velocity. Calculating the values using the standard formula yields 50,000 J for P, 100,000 J for Q, 25,000 J for R, and 45,000 J for S. Vehicle Q possesses the highest energy because its doubled velocity heavily increases energy.

27. Carefully review these fundamental physics statements exactly regarding strictly conservative potential energy types:
1. Stretching a metal coil spring perfectly stores distinct elastic potential energy.
 2. Lifting a heavy wooden box strictly increases its total gravitational potential energy.
 3. Completely separating two mutually attracting opposite magnetic poles strictly decreases their combined magnetic potential energy.

Identify the strictly correct combination of these statements:

- (A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2, and 3

Ans : (A)

Potential energy can be stored through structural deformations or spatial arrangements. A stretched spring stores elastic potential energy due to its forced configuration. Gravitational potential energy depends precisely on height relative to the Earth's surface. A system involving two separated magnetic poles also clearly stores magnetic

potential energy due to their specific relative spatial positions.

28. According to the strict fundamental scientific principle of completely conservative mechanical energy, what exactly occurs strictly to an object steadily falling freely downwards under pure uninterrupted earthly gravity?
- (A) Its total combined mechanical energy steadily dissipates entirely into zero.
(B) Its kinetic energy fundamentally drops strictly while potential energy steadily increases.
(C) Its gravitational potential energy steadily decreases strictly while kinetic energy precisely increases.
(D) Its total mechanical energy continually increases strictly due to rapid gravitational acceleration.

Ans : (C)

According to the fundamental law of conservation of mechanical energy, if an object falls freely under only the influence of gravity, neglecting air resistance, its total mechanical energy remains perfectly constant. As it descends, its stored gravitational potential energy continuously decreases, transforming precisely and completely into increasing kinetic energy without any overall net energy loss.

29. Correctly arrange the following sequential energy transformation stages specifically tracking a heavy stone dropped perfectly straight downwards from a remarkably tall vertical cliff:
1. Stone hits the sandy ground and dynamically completely halts moving.
 2. Gravitational potential energy dynamically begins smoothly converting entirely into kinetic energy.
 3. Stone strictly possesses maximum absolute potential energy and precisely zero moving kinetic energy.
 4. Stone distinctly possesses strictly maximum moving kinetic energy exactly just before immediate ground impact.

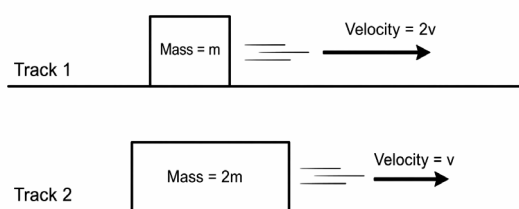
Select the precise correct chronological sequential order of events:

- (A) 3, 2, 4, 1
(B) 2, 3, 4, 1
(C) 3, 4, 2, 1
(D) 4, 2, 3, 1

Ans : (A)

A freely falling object starts from a certain height possessing maximum potential energy and zero kinetic energy. As it descends, gravitational potential energy gradually transforms into kinetic energy. Just before impacting the ground, its kinetic energy reaches a maximum while potential energy becomes zero, followed finally by impact and complete cessation of the object's motion.

30. Consider the two moving blocks shown in the diagram. What is the ratio of the kinetic energy of the block on Track 1 to the kinetic energy of the block on Track 2?



- (A) 1:1
(B) 1:2
(C) 2:1
(D) 4:1

Ans : (C)

Kinetic energy depends on mass and the square of velocity ($K = \frac{1}{2}mv^2$). For the first block, kinetic energy is $\frac{1}{2}m(2v)^2 = 2mv^2$. For the second block, kinetic energy is $\frac{1}{2}(2m)v^2 = mv^2$. The ratio is $2mv^2$ to mv^2 , which simplifies exactly to 2:1, making the other given ratios mathematically incorrect.

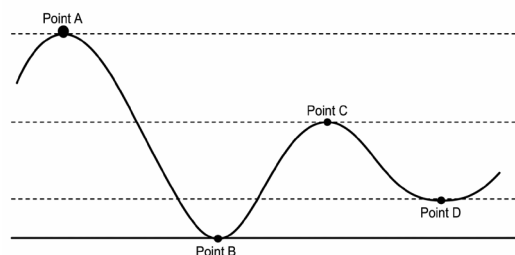
31. In a standard purely oscillating simple laboratory pendulum steadily swinging freely backwards and continuously forwards, exactly at which precise structural point does it genuinely possess absolutely purely pure kinetic energy?
- (A) Precisely at its highest absolute extreme raised position points.
(B) Precisely at its absolute lowest central mean swing position.
(C) Exactly halfway cleanly between the mean and the extreme positions.
(D) Strictly at both completely extreme end raised points simultaneously.

Ans : (B)

In a steadily oscillating simple pendulum, mechanical energy cyclically shifts between forms. At the extreme swing positions, the pendulum momentarily halts, possessing maximum potential energy and absolutely zero kinetic energy. As it swings through the central mean position, its vertical height is lowest, converting its potential energy entirely into maximum kinetic energy at that specific instant.

32. The sphere is released from rest at Point A and rolls along the frictionless track. At which point will the sphere have the maximum kinetic energy?

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- (A) Point A
(B) Point B
(C) Point C
(D) Point D

Ans : (B)

According to the law of conservation of mechanical energy, potential energy transforms into kinetic energy as an object descends. The total mechanical energy remains constant. The sphere's kinetic energy is maximized when its gravitational potential energy is minimized, which occurs at the lowest elevation on the track. Therefore, Point B represents the maximum kinetic energy.

33. Examine the following detailed theoretical physics statements entirely concerning the strict universal law governing strictly pure unresisted mechanical energy conservation principles:
1. Total completely pure mechanical energy is universally strictly defined perfectly as only potential energy minus kinetic energy.
 2. Perfect mechanical energy genuinely strictly remains completely constant exclusively in situations lacking non-conservative forces like frictional drag.
 3. A downward free falling mass strictly continuously transforms precisely all losing potential energy perfectly entirely into equal kinetic energy.

work effectively translates into equivalent gains in kinetic or gravitational potential energy respectively.

11. A solid sphere is dropped from a certain height and falls freely under the influence of gravity. The energy values at three different positions during its fall are recorded. What are the correct numerical values for P and Q in the table?

Position during fall	Potential Energy (J)	Kinetic Energy (J)	Total Mechanical Energy (J)
Position A (Highest point)	200	0	200
Position B (Midway point)	120	P	200
Position C (Just before impact)	0	200	Q

- (A) P = 120, Q = 120
 (B) P = 80, Q = 200
 (C) P = 0, Q = 200
 (D) P = 80, Q = 0

Ans : (B)

According to the fundamental law of conservation of mechanical energy, the total mechanical energy of a freely falling object remains completely constant. Since the total energy is 200 J at position A, it remains 200 J everywhere. Therefore, Q is 200 J. At position B, kinetic energy P equals total energy minus potential energy, yielding 80 J.

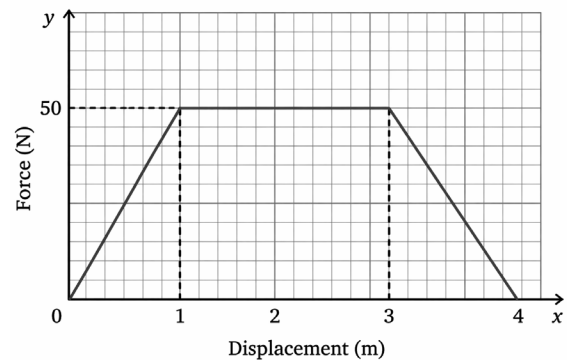
12. What is the mathematically correct standard formula precisely defining the kinetic energy possessed by a structurally solid object of mass m uniformly moving with continuous velocity v ?
- (A) $K = mv$
 (B) $K = mv^2$
 (C) $K = \frac{1}{2}mv^2$
 (D) $K = mgh$

Ans : (C)

Kinetic energy represents the energy possessed by an object strictly due to its motion. The standard mathematical expression for calculating kinetic energy is one-half multiplied by the mass and the square of the velocity. Because mass is positive and velocity is squared, the kinetic energy of any

moving physical object can never be a negative value.

13. The given graph illustrates a variable force acting on a block along its direction of motion. If the block starts from rest at the origin, what physical quantity represents its kinetic energy after it has been displaced by four metres?



- (A) The steep slope of the line calculated from zero to two metres.
 (B) The maximum value of the force applied at exactly two metres.
 (C) The total area under the force-displacement curve up to four metres.
 (D) The product of the maximum force and total horizontal displacement.

Ans : (C)

According to the work-energy theorem, the work done on an object equals its change in kinetic energy. For a force-displacement graph, the total work done is calculated by finding the area under the curve. Therefore, the total area bounded by the graph and the horizontal axis directly represents the kinetic energy gained by the moving block.

14. If the exact magnitude of the continuous moving velocity of a moving car strictly doubles during a highway journey, how does its new kinetic energy specifically compare to its original initial value?
- (A) It becomes exactly half of its original value.
 (B) It accurately remains perfectly the same.
 (C) It precisely doubles directly like the velocity.
 (D) It rapidly becomes exactly four times larger.

Ans : (D)

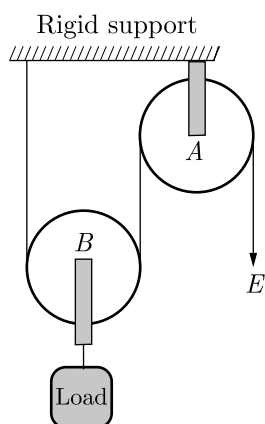
The kinetic energy of an object is directly proportional to the square of its velocity. If a vehicle's velocity strictly doubles, the new velocity becomes twice the original. Squaring this new velocity factor results in a fourfold

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The assertion correctly states that a freely falling object maintains constant mechanical energy. The precise reason is the continuous, perfectly balanced transformation between potential and kinetic energy. Every single joule of gravitational potential energy lost during descent is instantaneously and exactly converted into a joule of kinetic energy, maintaining the overall total sum completely invariable.

37. In the diagram shown below, the velocity ratio of the arrangement is



- (a) 1
 (c) 3
 (b) 2
 (d) 0

Ans :

SEM-I, 2021

$$\begin{aligned}\text{Velocity ratio} &= \frac{d_E}{d_L} \\ &= \frac{2d}{d} = 2\end{aligned}$$

Thus (b) is correct option.

38. A single fixed pulley is used because
 (a) it changes the direction of applied effort conveniently
 (b) it multiplies speed
 (c) it multiplies effort
 (d) its efficiency is 100%

Ans :

SEM-I, 2021

A single fixed pulley is used to lift load by changing the direction of the lifting force. Even though a

single fixed pulley has no mechanical gain in that, the effort applied is greater than the load. Thus (a) is correct option.

39. What is the ratio of load to effort in case of a tree house elevator shown in the diagram below?



- (b) 2 : 1
 (c) 1 : 2
 (b) 1 : 1
 (d) none of the above

Ans :

COMP 2001

Tree house elevator is using single fixed pulley so ratio of load to effort is 1 : 1

Thus (b) is correct option.

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40. Mechanical advantage is ratio of

- (a) effort to load
 (b) useful effort to load
 (c) useful load to useful effort
 (d) load to effort

Ans :

MAIN 2013

Mechanical advantage is the ratio of load to the effort.

Thus (d) is correct option.

41. A pulley is used to lift a load of 180 kgf by applying an effort of 90 kgf in the downward direction. Calculate the work done by the effort applied on the pulley.

- (a) 24 J
 (c) 12 J
 (b) 6 J
 (d) 2 J

Ans :

MAIN 2008

$$\text{Load} = 180 \text{ kgf}$$

$$\text{Effort} = 90 \text{ kgf}$$

$$\begin{aligned}\text{Velocity ratio} &= \frac{\text{displacement of effort}}{\text{displacement of load}} \\ &= \frac{180}{90} = 2\end{aligned}$$

Thus (d) is correct option.

42. A woman draws water from a well using a fixed pulley. The mass of the bucket and the water together is 10 kg. The force applied by the woman is 200 N. The mechanical advantage is (Take $g = 10 \text{ m/s}^2$)

(a) 2 (b) 20
(c) 0.05 (d) 0.5

Ans :

SEM-I, 2021

Load = weight of water

$$L = 10 \times 10 \text{ N} \\ = 100 \text{ N}$$

Effort = force applied

$$E = 200 \text{ N}$$

Now,

$$MA = \frac{\text{Load}}{\text{Effort}} \\ = \frac{100}{200} = 0.5$$

Thus (d) is correct option.

43. Name the pulley system used in the following application of lifting scrap from a junk yard:



- (a) Block and tackle system of pulleys.
(b) Single fixed pulley.
(c) Combination of single fixed and single movable pulley.
(d) Single movable pulley.

Ans :

MAIN 2012

Crane is an example of block and tackle for greater MA.

Thus (a) is correct option.

44. The handle of a nutcracker is 16 cm long and a nut is placed 2 cm from its hinge. If a force of 4 kgf is applied at the end of the handle to crack it, what weight, if simply, placed on the nut will crack it ?

(a) 15 kgf (b) 32 kgf
(c) 4 kgf (d) 9 kgf

Ans :

COMP 2013

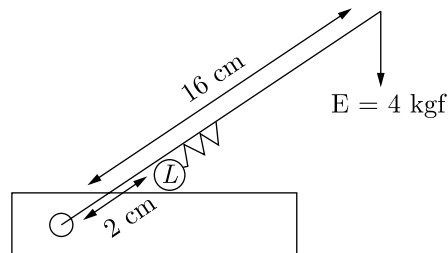
$$\text{Effort arm} = 16 \text{ cm} = \frac{16}{100} \text{ m}$$

$$\text{Effort } E = 4 \text{ kgf}$$

$$\text{Load arm} = 2 \text{ cm} = \frac{2}{100} \text{ m}$$

Suppose,

$$\text{Load} = L$$



$$L \times \text{load arm} = E \times \text{effort arm}$$

$$L \times \frac{2}{100} = 4 \times \frac{16}{100}$$

$$L = \frac{64}{100} \times \frac{100}{2}$$

$$= 32 \text{ kgf}$$

Thus (b) is correct option.

45. The actual mechanical advantage of a single movable pulley is :

(a) two
(b) less than 2, but more than 1
(c) one
(d) none of these

Ans :

SQP 2007

Thus (b) is correct option.

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46. A pulley system has a $VR = 5$. If the efficiency of the system is 80%, find its MA.

(a) 4 (b) 3
(c) 2 (d) 1

Ans :

MAIN 2010

$$VR = 5, \text{ efficiency} = 80\%$$

$$\frac{MA}{VR} = \text{Efficiency}$$

$$80 = \frac{MA}{5}$$

$$MA = \frac{80}{100} \times 5 = 4$$

Thus (a) is correct option.

47. A single fixed pulley is used because :
- it multiplies effort
 - it multiplies speed
 - its efficiency is 100%
 - it changes the direction of applied effort

Ans :

SQP 2008

A single fixed pulley does not reduce the effort but helps in changing the direction of effort applied. As it is far easier to apply effort in a downward direction, the single fixed pulley is widely used. Thus (d) is correct option.

48. What is the MA and VR of the machine shown in the figure below:



- $MA = 2$ and $VR = 2$
- $MA = 2$ and $VR = 1$
- $MA = 1$ and $VR = 1$
- $MA = 1$ and $VR = 2$

Ans :

COMP 2003

The pulley used is single fixed hence MA and VR are 1. Thus (c) is correct option.

VERY SHORT ANSWER

49. Define the scientific concept of work done by a constant force on an object.

Ans :

Work done by a constant force is defined as the product of the force applied and the displacement of the object in the force's direction.

50. What is the SI unit of work and how is it defined using force and displacement?

Ans :

The SI unit of work is the joule, which is defined as one newton of force causing a displacement of one metre in its direction.

51. Under what specific condition does the force applied on a moving object result in zero work being done?

Ans :

Work done is zero when the applied force acts in a direction that is exactly perpendicular to the displacement of the moving object.

52. Give one example from everyday life where negative work is done by a force on an object.

Ans :

When a goalkeeper stops a moving football, he applies a force in the direction opposite to its displacement, thereby doing negative work on it.

53. What would you observe about the work done when you continuously push a rigid wall without moving it?

Ans :

You would observe that the work done on the wall is zero because there is absolutely no displacement of the wall despite the applied force.

54. State the work-energy theorem regarding the relationship between work done and the energy of an object.

Ans :

The work-energy theorem states that the work done on an object or a system of objects is exactly equal to the change in its energy.

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55. Who is the SI unit of energy named after, and what significant relationship did he study in science?

Ans :

The SI unit is named after James Prescott Joule, who studied how mechanical energy and thermal energy are related and converted into each other.

56. Name the distinct form of energy that is stored within the fuels we burn and the food we consume daily.

Ans :

The distinct form of energy stored within the fuels we burn and the food we consume daily is scientifically known as chemical potential energy.

- 57.** What is the cause of a moving cricket ball transferring energy to the stationary wickets when it strikes them?

Ans :

The moving cricket ball transfers energy because its kinetic energy allows it to apply a force on the wickets, causing them to move upon impact.

- 58.** What is kinetic energy in the context of mechanical energy?

Ans :

Kinetic energy is a specific type of mechanical energy that an object possesses purely by virtue of its motion and the velocity it has acquired.

- 59.** Write the mathematical formula used to calculate the kinetic energy of an object of mass m moving with a velocity v .

Ans :

The mathematical formula used to calculate the kinetic energy of an object of mass m moving with a velocity v is one half mv squared.

- 60.** What would happen to the kinetic energy of a moving vehicle if its velocity suddenly doubles in magnitude?

Ans :

If the velocity of the moving vehicle suddenly doubles in magnitude, its kinetic energy will predictably increase to exactly four times its original initial value.

- 61.** State one characteristic property of kinetic energy regarding its direction and dependency on positive work.

Ans :

Kinetic energy is a scalar quantity lacking direction, and its magnitude always increases whenever positive work is done on the object by external forces.

- 62.** What is the significance of the physical deformation of a stretched rubber band in terms of energy?

Ans :

The deformation of a stretched rubber band is highly significant because the work done to stretch it gets stored within it as elastic potential energy.

- 63.** Why does raising an object to a greater height above the ground result in a deeper depression in sand?

Ans :

Raising the object higher increases its gravitational potential energy, which converts into greater kinetic energy upon falling, thereby causing a much deeper sandy depression.

- 64.** What is the mathematical expression for the gravitational potential energy of an object of mass m raised to a specific height h ?

Ans :

The mathematical expression for the gravitational potential energy of an object of mass m raised to a specific height h is given by mgh .

- 65.** What causes internal forces to store potential energy when unlike poles of two magnets are forcefully separated?

Ans :

Separating the unlike magnetic poles requires external work against their mutual attractive forces, and this specific work is safely stored as potential energy.

- 66.** Define mechanical energy in relation to the different energy forms possessed by a physical object.

Ans :

Mechanical energy is defined simply as the exact sum total of the kinetic energy and the potential energy possessed by an object together.

- 67.** State the law of conservation of mechanical energy for an object falling freely under gravity.

Ans :

As an object falls freely under gravity, its total mechanical energy remains entirely constant provided that absolutely no other external forces act upon it.

- 68.** What is the result of potential energy decreasing as a freely falling object accelerates toward the ground?

Ans :

As the potential energy decreases during the free fall, it is completely converted into an exactly equal amount of increasing kinetic energy over time.

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69. Why does a swinging simple pendulum eventually stop oscillating in real-life situations despite the conservation of energy?

Ans :

A simple pendulum eventually stops oscillating because its initial mechanical energy is gradually lost due to air resistance and friction at the fixed support.

70. What is the definition of power in the context of physics and doing work?

Ans :

In physics, power is defined accurately as the total rate at which work is done or the rate of energy transfer over absolute time.

71. What is the SI unit of power and how does it precisely relate to the standard unit of work?

Ans :

The SI unit of power is the watt, and one watt represents exactly one joule of work being done in an interval of one second.

72. State one difference between running up a flight of stairs and walking up slowly in terms of power.

Ans :

Running up the stairs requires much more power than walking slowly because the exact same amount of work is performed in a shorter time.

73. What is the primary function of simple machines in our daily lives regarding the application of forces?

Ans :

Simple machines function to make our daily tasks significantly easier by efficiently altering the magnitude or the direction of the applied effort force required.

74. Write the formula used to calculate the mechanical advantage of any simple machine in terms of load and effort.

Ans :

The mechanical advantage of a simple machine is calculated as the precise ratio of the total load overcome to the external effort force successfully applied.

75. Give one example of a Class I lever and identify the central component in its structural arrangement.

Ans :

A pair of scissors is a Class I lever, where the fixed fulcrum is located firmly between the applied effort force and the final load.

76. How does a fixed pulley make lifting heavy loads easier if it does not inherently reduce the required effort?

Ans :

A fixed pulley provides immense convenience by simply changing the direction of the applied effort downwards, which is much easier than lifting loads straight upwards.

77. Describe the fundamental structure of an inclined plane and how it successfully provides a mechanical advantage.

Ans :

An inclined plane is a flat supporting surface tilted at an angle, allowing massive loads to be raised efficiently using distinctly less applied effort force.

78. Correct the following statement: Simple machines create extra energy to help us do work more effectively without effort.

Ans :

Simple machines never create energy; they merely help us use applied energy more effectively while strictly obeying the fundamental law of mechanical energy conservation.

SHORT ANSWER QUESTIONS

79. Define work in a scientific context. How is it calculated when a constant force and the displacement of an object are in the same direction?

Ans :

In science, work is said to be done when a constant force acts on an object and causes it to be displaced. It is a measure of the energy transferred. When the force and displacement are in the same direction, the work done is defined as the product of the magnitude of the applied force and the displacement of the object. Mathematically, it is expressed as $\text{Work} = \text{Force} \times \text{Displacement}$.

Ans :

A lever allows a smaller effort force to lift a heavier load by increasing the distance between the effort and the fulcrum, known as the effort arm. According to the principle of levers, the product of effort and effort arm equals the product of load and load arm. To gain this mechanical advantage, the trade-off is distance. The end of the lever where the smaller effort is applied must move through a much greater distance to move the heavy load over a significantly smaller distance.

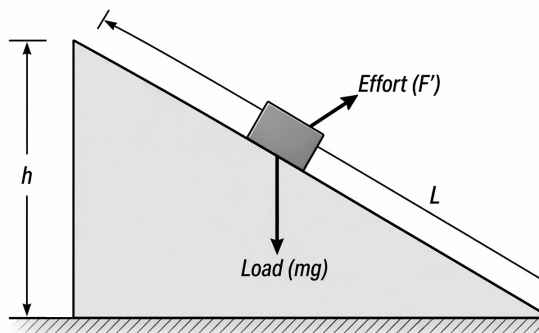
102. What would happen if a simple machine, like a system of movable pulleys, could operate with absolutely zero friction? Discuss its efficiency and the work done.

Ans :

If a simple machine like a pulley system operated with absolutely zero friction, it would be an ideal or perfect machine. In this hypothetical scenario, no energy would be lost as thermal energy or sound due to friction. The mechanical energy would be entirely conserved, meaning the total work output of the machine would be exactly equal to the work input provided by the effort. The machine would achieve 100% efficiency, effectively converting every joule of applied work into useful work done on the load.

103. Draw a simple diagram showing a heavy block being pulled up an inclined plane. If the height of the plane remains the same but its length is doubled, how does this affect the mechanical advantage?

Ans :



The mechanical advantage of an inclined plane is calculated by the ratio of its length to its height (L/h). Since the total work done remains constant, pushing an object up a slope requires

applying effort over the length of the plane. If the height remains the same but the length (L) is doubled, the slope becomes much gentler. The mechanical advantage is therefore doubled, which means the required effort force to pull the heavy block up the plane is reduced to half.

104. When a fast-moving truck applies its brakes and skids to a complete stop on a highway, what happens to its kinetic energy?

Ans :

When a moving truck applies its brakes and skids, it initially possesses a large amount of kinetic energy due to its motion. As the brakes lock and the tires skid against the rough road surface, a strong frictional force opposes the truck's motion. This frictional force does negative work on the truck. The truck's kinetic energy does not disappear but is entirely transformed into thermal energy (heat) and sound energy due to the intense friction between the tires and the road surface, eventually bringing it to rest.

105. Describe the continuous energy transformations that take place in a traditional Himalayan watermill (panchakki) from the time water flows down the hill to the grinding of grain.

Ans :

In a traditional Himalayan watermill, the process begins with water stored or flowing from a high altitude, which possesses significant gravitational potential energy. As this water flows downhill through pipes or channels, its height decreases and its speed increases, converting the potential energy into kinetic energy. This fast-moving water strikes the blades of a wooden turbine or wheel at the bottom, transferring its kinetic energy to make the wheel rotate. The rotating wheel turns the grinding stone above it, using the mechanical energy to crush grains.

106. What type of energy is stored in a stretched rubber band? How does the amount of stretch affect the distance a projectile attached to it will travel?

Ans :

When a rubber band is stretched, it is deformed from its original shape, and the work done by the pulling force is stored as elastic potential energy. If a small projectile is attached and the band is released, this stored potential energy quickly converts into kinetic energy. The amount

$$s = v^2 / 2a.$$

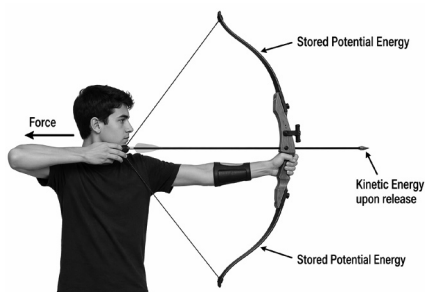
Substituting these into the work equation gives,

$$W = ma \times (v^2 / 2a) = \frac{1}{2} mv^2.$$

By the work-energy theorem, this work equals the kinetic energy.

86. Draw a labelled diagram showing a person shooting an arrow using a stretched bow. Explain how potential energy converts into kinetic energy in this action.

Ans :



When the archer applies a force to pull the string, work is done to deform the bow's shape. This work is stored as elastic potential energy in the bent limbs of the bow. When the string is released, the bow rapidly returns to its original unstretched shape. In doing so, the stored potential energy is immediately transferred to the arrow, converting entirely into kinetic energy, causing the arrow to fly forward at high speed.

87. Why does the kinetic energy of a fast-moving car increase four times when the driver suddenly doubles its speed? Explain using the relevant formula.

Ans :

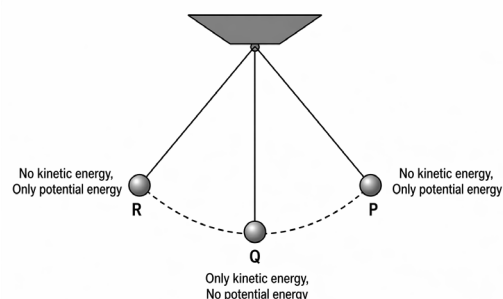
The kinetic energy of a moving object depends on its mass and its velocity, given by the mathematical formula $K = \frac{1}{2} mv^2$.

The mass of the car remains constant, but the kinetic energy is directly proportional to the square of its velocity (v^2).

When the driver doubles the speed from ' v ' to ' $2v$ ', the new kinetic energy becomes $\frac{1}{2} m(2v)^2 = \frac{1}{2} m (4v^2)$. Therefore, a twofold increase in velocity results in a fourfold increase in the car's overall kinetic energy.

88. Draw a diagram of a simple swinging pendulum showing its extreme and mean positions. Explain how the conservation of mechanical energy applies to its motion.

Ans :



As the pendulum moves from an extreme position (P) to the central mean position (Q), its vertical height decreases, meaning its gravitational potential energy decreases. Simultaneously, its speed increases, converting the lost potential energy into kinetic energy. At Q, kinetic energy is maximum and potential energy is minimum. As it swings toward the other extreme (R), kinetic energy converts back to potential energy. Ignoring air resistance, the sum of kinetic and potential energy (total mechanical energy) remains constant throughout.

89. Compare kinetic energy and potential energy with respect to their fundamental cause and provide one distinct everyday example for each.

Ans :

Kinetic energy is the energy possessed by an object by virtue of its physical motion, whereas potential energy is the stored energy an object has due to its specific position, shape, or configuration relative to other objects. An example of kinetic energy is a fast-moving cricket ball, which can do work by knocking over wickets. An example of potential energy is water stored at a height behind a dam, which holds gravitational potential energy due to its elevated position before it falls.

90. Explain the concept of gravitational potential energy. Write its mathematical expression and state the variables it depends on.

Ans :

Gravitational potential energy is the energy stored in an object due to its vertical position or height above the surface of the Earth. When work is done against gravity to lift an object to a certain height, that work is stored as gravitational potential energy. Its mathematical expression is $U = mgh$. This equation shows that the gravitational potential energy of an object depends directly on three factors: the object's mass (m), the acceleration due to gravity (g), and its height (h) above the ground.

$\times$ displacement ($W = F \times s$). The SI unit of work is the joule (J).

80. What are the two specific conditions under which the work done by a force on an object is considered zero? Give one example from daily life to support your answer.

Ans :

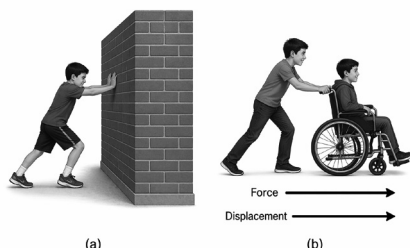
Work done is zero if either the displacement of the object is zero, or if the applied force is perpendicular to the direction of displacement. For example, if you push hard against a rigid, immovable wall, you may feel physically tired from muscle contractions, but the scientific work done on the wall is zero because the displacement of the wall is zero. Similarly, a person carrying a heavy box horizontally does zero work against gravity because the upward force is perpendicular to horizontal displacement.

81. A student claims that a goalkeeper catching a fast-moving football does positive work on the ball because he uses a lot of energy to stop it. Do you agree? Justify your answer.

Ans :

I disagree with the student's claim. When a goalkeeper stops a fast-moving football, the goalkeeper's hands apply a stopping force on the ball in the outward direction. However, the ball still travels a short distance backward into the goalkeeper's hands before coming to a complete stop. Because the applied force and the displacement of the ball are in opposite directions, the work done by the goalkeeper on the ball is negative, not positive. Positive work requires force and displacement in the same direction.

82.



- (a) Identify in which case work is being done and in which case it is not.
 (b) Explain the scientific reason behind your identification.

Ans :

- (a) Work is being done in case (b) where the boy pushes the wheelchair, but no work is done in case (a) where the boy pushes the wall.
 (b) According to the scientific definition, work requires both an applied force and a displacement of the object. In case (a), despite applying force, the wall's displacement is zero, resulting in zero work. In case (b), the wheelchair undergoes a displacement in the same direction as the applied force, resulting in positive work being done on the wheelchair.

83. Explain the concept of the work-energy theorem. How are the work done on an object and its energy connected?

Ans :

The work-energy theorem states that the work done on an object is equal to the change in its energy. When positive work is done on an object, it gains energy, which gives it the capacity to do further work or apply force to another object. For example, when a fielder throws a cricket ball, he does work on the ball, transferring energy to it. The ball gains kinetic energy, which it later uses to do work on the stumps by knocking them over.

84. Define kinetic energy. How is it related to the mass and velocity of a moving object?

Ans :

Kinetic energy is the energy possessed by an object strictly due to its motion. Any moving object, such as a rolling ball or a flying bird, possesses kinetic energy. The kinetic energy of an object is directly proportional to its mass and the square of its velocity. It is mathematically expressed as $K = \frac{1}{2}mv^2$. This means that if the mass of the moving object increases, its kinetic energy increases. Similarly, if the object's velocity is doubled, its kinetic energy increases by four times.

85. Derive the mathematical expression for the kinetic energy of an object of mass 'm' moving with a velocity 'v', starting from rest.

Ans :

Consider an object of mass 'm' starting from rest (initial velocity $u = 0$). A constant force 'F' causes a displacement 's', giving it a final velocity 'v' with constant acceleration 'a'.

$$\text{Work done, } W = F \times s \quad \dots(i)$$

According to Newton's second law, $F = ma$. Using the kinematic equation $v^2 - u^2 = 2as$,

96. Define mechanical advantage. What is the formula to calculate it, and what does a mechanical advantage greater than 1 signify?

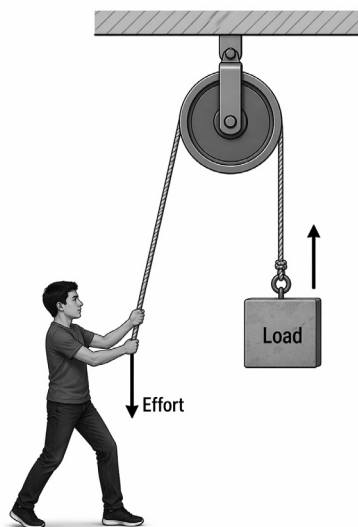
Ans :

Mechanical advantage is a ratio that describes how a machine changes the magnitude of the applied force to overcome a load. It is calculated using the formula: $\text{Mechanical Advantage} = \text{Load} / \text{Effort}$. When a simple machine has a mechanical advantage greater than 1, it means the machine acts as a force multiplier. This signifies that the machine allows a person to lift or move a heavy load by applying an effort force that is much smaller than the actual weight of the load.

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97. Draw a labelled diagram of a simple fixed pulley used to lift a load. Explain why it is widely used even though its mechanical advantage is only 1.

Ans :



A fixed pulley does not multiply the applied force, which is why its mechanical advantage is exactly 1; the effort equals the load. However, it is widely used because it changes the direction of the effort force. Instead of lifting a heavy load vertically upward against gravity which is awkward and strenuous a person can conveniently pull the rope downward. Pulling downward allows the person to use their own body weight to assist in applying the necessary effort, making the task practically easier.

98. Why do hilly roads wind around gentle slopes rather than going straight up the mountain? Explain using the concept of inclined planes and work.

Ans :

Hilly roads are designed as winding inclined planes to make ascending the mountain easier for vehicles. If a road went straight up, it would be a very steep incline, requiring a massive engine effort to overcome gravity over a short distance. By winding around the hill, the road creates a gentle slope, significantly increasing the total distance traveled. Since the total work done (force $\times$ distance) to reach the peak remains constant, increasing the distance reduces the required effort force, making it safer and easier for vehicles.

99. Describe the structure of a simple lever. Define the three main parts of a lever and explain how they interact to lift an object.

Ans :

A lever is a simple machine consisting of a rigid bar that is free to rotate around a fixed pivot point. It has three main parts: the fulcrum, which is the fixed point of rotation; the load, which is the heavy object or force that needs to be overcome; and the effort, which is the force applied by the user to move the load. By applying a small effort force at a longer distance from the fulcrum, the lever amplifies this force to lift a heavier load placed closer to the fulcrum.

100. Compare Class I and Class II levers with respect to the relative positions of their fulcrum, load, and effort. Give one real-life example of each class.

Ans :

In a Class I lever, the fulcrum is positioned squarely between the applied effort and the load. A common real-life example of a Class I lever is a pair of scissors or a playground seesaw. In contrast, in a Class II lever, the load is positioned directly between the fulcrum and the applied effort. A practical everyday example of a Class II lever is a wheelbarrow or a lemon squeezer. Both types offer different ways to manipulate force and distance.

101. How does a lever allow a smaller effort force to lift a much heavier load? What is the trade-off regarding the distance the effort must move?

91. Renu observes a falling apple and says that as the apple falls, its total mechanical energy keeps decreasing until it hits the ground. Do you agree? Justify your answer.

Ans :

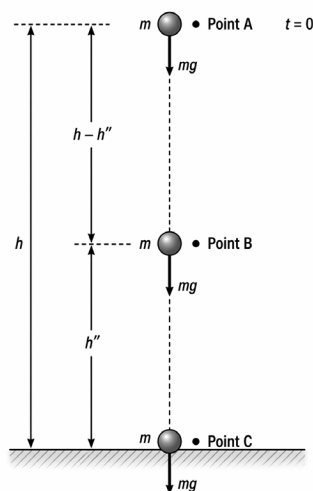
I disagree with Renu's statement. According to the law of conservation of mechanical energy, if no external forces like severe air resistance act on an object, its total mechanical energy remains constant. As the apple falls freely towards the ground, its height decreases, meaning its gravitational potential energy decreases. However, its velocity increases simultaneously, causing an exact and equal increase in its kinetic energy. The sum of the kinetic and potential energies remains perfectly constant throughout the entire fall.

92. Define power. How does running up a flight of stairs in one minute differ from walking up the same stairs in five minutes in terms of work and power?

Ans :

Power is defined as the rate at which work is done or energy is transferred. Its SI unit is the watt (W). When running up a flight of stairs in one minute versus walking up in five minutes, the total work done against gravity is exactly the same in both scenarios because the vertical height and the person's mass remain unchanged. However, running requires more power because the same amount of work is completed in a much shorter time interval.

93. A situation is shown in the given figure



- (a) What are the kinetic and potential energies of the ball at Point A?
(b) Describe the energy transformation as the ball falls from A to C.

Ans :

- (a) At point A, the ball is at rest before falling, so its initial velocity is zero. Therefore, its kinetic energy is zero, and it possesses maximum gravitational potential energy equal to mgh .
(b) As the ball falls from A towards C, its height above the ground continuously decreases, which reduces its potential energy. At the same time, its downward velocity increases due to gravity, which increases its kinetic energy. The lost potential energy is smoothly converted into kinetic energy, keeping total mechanical energy conserved.

94. Describe the sequence of steps required to calculate the power of a water pump lifting a specific mass of water to a rooftop tank in a given time.

Ans :

To calculate the power of the water pump, first, determine the mass of the water (m) to be lifted. Next, measure the vertical height (h) from the ground to the rooftop tank. Calculate the work done against gravity by finding the gravitational potential energy gained using the formula $W = mgh$, where g is the acceleration due to gravity. Finally, measure the time (t) taken to lift the water. Divide the calculated work done by the time taken ($P = W/t$) to find the pump's power in watts.

95. What are simple machines? Explain how they help us perform tasks more conveniently, even though they do not reduce the total amount of work required.

Ans :

Simple machines are basic mechanical devices, such as pulleys, levers, and inclined planes, that make our work easier. Although they cannot reduce the total physical work required to complete a task due to the conservation of energy, they make the task more convenient. They do this either by reducing the magnitude of the effort force needed (by applying a smaller force over a larger distance) or by changing the direction of the applied force to a more comfortable orientation, like pulling downwards instead of lifting upwards.

of stretch directly dictates the energy stored. Therefore, pulling the rubber band further back stores a greater amount of potential energy, which translates into a higher kinetic energy and a faster, longer-distance flight for the projectile.

107.



- Based on the diagram, which part represents the effort and which part represents the load?
- Explain why the seesaw remains balanced despite the vast difference in their weights.

Ans :

- The heavy adult seated on the left represents the load, while the lighter child seated on the right represents the effort applied to balance the system.
- The seesaw balances because a lever operates on the principle that effort multiplied by effort arm equals load multiplied by load arm. The adult has a larger weight (load) but sits very close to the fulcrum (short load arm). The child has a smaller weight (effort) but sits much further away (long effort arm). These products equalize, keeping the board perfectly horizontal.

LONG ANSWER QUESTIONS

- What is the definition of work done by a constant force?
 - Under what conditions is the work done by a force considered positive, negative, and zero, giving one example for each condition?

Ans :

- Work is scientifically defined as being done when a constant force acting on an object causes a displacement of the object in the direction of the applied force. The formula is $W = F \times s$.

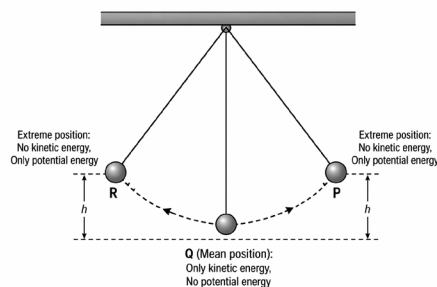
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- Work is positive when the force and displacement are in the same direction, such as pushing a wheelchair forward to accelerate it. It is negative when the force acts opposite to the object's displacement, like a goalkeeper applying force to stop a moving football, which removes kinetic energy. Work is zero if the force and displacement are perpendicular, or if there is no displacement. For example, carrying a heavy box while walking horizontally does zero work on the box against gravity because the upward holding force and horizontal displacement are at a ninety-degree angle. Pushing a rigid wall also yields zero work.

- What does a diagram of a simple pendulum showing its extreme and mean positions look like?
 - How does the mechanical energy transform as the pendulum bob swings?
 - Why does a real pendulum eventually stop oscillating?

Ans :

-



- As the pendulum bob swings, its mechanical energy continuously transforms between potential and kinetic forms. At the extreme positions (P and R), the bob momentarily stops, so its kinetic energy is zero, and its gravitational potential energy is maximum. As it falls towards the mean position (Q), it loses height and gains speed. Its potential energy decreases, converting entirely into kinetic energy. At Q, the kinetic energy is maximum and potential energy is zero. Moving past Q, kinetic energy converts back to potential energy until it reaches the other extreme. This demonstrates the conservation of mechanical energy, where the total sum remains constant.

- (c) However, a real pendulum eventually stops oscillating because it continuously loses a small fraction of its energy due to friction at the pivot support and air resistance. This lost mechanical energy dissipates as heat.

- 110.** (a) What is the definition of potential energy?
 (b) How do you derive the expression for the gravitational potential energy of an object at a height 'h'?
 (c) If a 5 kg mass is raised to a height of 10 m, what is the energy stored in it? (Take $g = 10 \text{ m/s}^2$)

Ans :

- (a) Potential energy is the energy stored by an object due to its position, configuration, or deformation.
 (b) To derive the expression for gravitational potential energy, consider an object of mass m lying on the ground. To lift it to a height h at a constant velocity, an upward force equal to the gravitational force (mg) must be applied. The work done on the object against gravity is $W = \text{force} \times \text{displacement}$, which gives $W = mg \times h = mgh$. This work done is stored entirely in the object as gravitational potential energy (U), therefore, $U = mgh$.
 (c) For the numerical, given mass $m = 5 \text{ kg}$, height $h = 10 \text{ m}$, and acceleration due to gravity $g = 10 \text{ m/s}^2$. Substituting these given values into the derived formula: $U = mgh = 5 \times 10 \times 10 = 500 \text{ J}$. The energy stored is 500 Joules.

- 111.** (a) What is meant by the power of a machine, and what is its SI unit?
 (b) If a water pump lifts 500 kg of water to an overhead tank at a height of 20 m in 100 seconds, what is the power of the pump? (Take $g = 10 \text{ m/s}^2$)

Ans :

- (a) Power is defined as the rate at which work is done or the rate at which energy is transferred by a machine. It describes how quickly or slowly a specific amount of work is accomplished. Mathematically, average power is calculated by dividing the total work done by the time taken ($P = W / t$). The SI unit of power is the watt (W), where one watt is equal to one joule of work done per second.

- (b) In the given scenario, the work done by the pump is equal to the gravitational potential energy gained by the water.

$$\text{Mass (m)} = 500 \text{ kg},$$

$$\text{Height (h)} = 20 \text{ m},$$

$$\text{Time (t)} = 100 \text{ s}, g = 10 \text{ m/s}^2.$$

$$\begin{aligned} \text{Work done (W)} &= mgh = 500 \times 10 \times 20 \\ &= 100,000 \text{ J}. \end{aligned}$$

$$\begin{aligned} \text{Power (P)} &= W / t \\ &= 100,000 \text{ J} / 100 \text{ s} \\ &= 1000 \text{ W}. \end{aligned}$$

The pump's power is 1000 Watts.

- 112.** (a) What is an inclined plane, and how does it act as a simple machine?
 (b) What is the formula for the mechanical advantage of an inclined plane?
 (c) If a person pushes a 600 N box up an inclined ramp that is 3 m long and 1 m high, what is the mechanical advantage and the ideal effort required?

Ans :

- (a) An inclined plane is a simple machine consisting of a flat, sloped surface that helps raise or lower heavy objects. It makes work easier by allowing a smaller effort force to move a heavy load over a greater distance, rather than lifting it vertically which requires a force equal to the object's entire weight.
 (b) The mechanical advantage (MA) of an inclined plane is defined as the ratio of its length to its vertical height ($MA = L / h$).
 (c) In the given problem, the length of the ramp (L) is 3 m and its height (h) is 1 m. The load (weight of the box) is 600 N.
 The mechanical advantage is

$$MA = 3 / 1 = 3.$$

Since, $MA = \text{Load} / \text{Effort}$, we can rearrange

this to find the ideal effort required:

$$\text{Effort} = \text{Load} / MA.$$

$$\text{Effort} = 600 \text{ N} / 3 = 200 \text{ N}.$$

- 113.** (a) What is the statement of the law of conservation of mechanical energy?
 (b) How do you prove that the total mechanical energy of a freely falling body of mass 'm' remains constant during its fall from a height 'h'?

Ans :

- (a) The law of conservation of mechanical energy states that the sum of the kinetic and potential energies of an object remains constant, provided no external non-conservative forces like friction act on it.
- (b) Consider an object of mass m falling freely from a height h . At the highest point, its velocity is zero. Hence, kinetic energy $K = 0$, and potential energy $U = mgh$. The total energy is $E = mgh$.
Let it fall for a time t to a height h' . Its velocity v becomes gt . From kinematic equations, the distance fallen is $h - h' = \frac{1}{2}gt^2$.

At height h' , $U = mgh'$.

Its kinetic energy is $K = \frac{1}{2}mv^2$

$$= \frac{1}{2}m(gt)^2$$

$$= \frac{1}{2}mg^2t^2.$$

Since $\frac{1}{2}gt^2 = h - h'$, $K = mg(h - h')$.

Total energy $E = K + U$

$$= mg(h - h') + mgh'$$

$$= mgh.$$

Thus, energy remains conserved.

114. (a) What are the energy transformations taking place in a hydroelectric power plant (water dam) and a glowing electric bulb?
- (b) What is the difference between mechanical energy and thermal energy?
- (c) Why do machines ultimately slow down and stop if fuel or electricity is cut off?

Ans :

- (a) In a hydroelectric dam, water stored at a height possesses gravitational potential energy. As water flows down, it converts into kinetic energy. This kinetic energy rotates the turbines, transforming into mechanical energy, which a generator then converts into electrical energy. In a glowing electric bulb, electrical energy is transformed into light energy and thermal (heat) energy.
- (b) Mechanical energy is the sum of kinetic and potential energy associated with the macroscopic motion or position of an object, like a rolling ball. Thermal energy, however, is the total kinetic energy of microscopic vibrating and colliding particles within a substance, which we perceive as heat.

- (c) Real machines eventually slow down and stop when external power is cut off because friction and air resistance continually act against their motion. These resistive forces constantly do negative work, converting the machine's mechanical energy into unwanted thermal energy, leading to a complete halt.

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115. Explain the scientific conception of work. Under what conditions is work said to be done by a force? Give examples where work is done and where work is not done despite effort.

Ans :

In science, work is said to be done when a force applied to an object causes a displacement of that object in the direction of the applied force. The two essential conditions for work to be done are:

1. A force must act on the object.
2. The object must be displaced.

Work done (W) is calculated as the product of the component of the force in the direction of displacement and the magnitude of the displacement ($W = F \cos \theta$, where θ is the angle between force and displacement. If force is in the direction of displacement, $W = Fs$).

Examples where work is done:

1. Lifting a book from a table (force and displacement are upwards).
2. Pulling a trolley (force and displacement are in the direction of pull).
3. A falling apple (gravitational force and displacement are downwards). Examples where work is not done despite effort : Pushing against a stationary wall: Force is applied, but displacement is zero ($W = 0$).
4. Holding a heavy suitcase stationary: Force is applied to counteract gravity, but there is no displacement of the suitcase ($W = 0$).

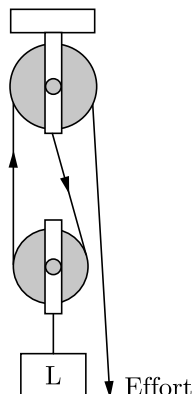
A person carrying a load on their head and walking horizontally does no work against gravity on the load, as the gravitational force is vertical and displacement is horizontal (angle is 90° , $\cos 90^\circ = 0$).

116. Define kinetic energy and potential energy. Derive the expression for kinetic energy of an object of mass ' m ' moving with velocity ' v '. What is the relationship between work done and change in kinetic energy?

Ans :

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(a)



(b) 1. $\text{Efficiency} = \frac{\text{M.A.}}{\text{V.R.}}$

$$0.8 = \frac{\text{M.A.}}{2}$$

$$\text{M.A.} = 1.6$$

2. $\text{Effort} = \frac{\text{Load}}{\text{M.A.}} = \frac{48}{1.6}$
 $= 30 \text{ kgf}$

NUMERICAL QUESTIONS

- 122.** A force of 10 N causes a displacement of 2 m in a body in its own direction. Calculate the work done by force.

Ans :

Given, Force, $F = 10 \text{ N}$

Displacement, $s = 2 \text{ meter}$

As we know that Work done by force,

$$W = F \times s = 10 \text{ N} \times 2 \text{ m} = 20 \text{ J}$$

- 123.** How much force is applied on the body when 150 joule of work is done in displacing the body through a distance of 10 m in the direction of force?

Ans :

Given, Work, $W = 150 \text{ J}$

Distance, $d = 10 \text{ m}$

As we know that,

$$W = F \times s$$

$$F = \frac{W}{s}$$

$$= \frac{150}{10} = 15 \text{ N}$$

- 124.** A body of 5 kg raised to 2 m find the work done.

Ans :

Given, Mass, $m = 5 \text{ kg}$

Height, $h = 2 \text{ m}$

The work done to raise a body

$$= \text{PE}$$

$$= mgh$$

$$= 5 \text{ kg} \times 9.8 \times 2 = 98 \text{ joule}$$

- 125.** A work of 4900 J is done on load of mass 50 kg to lift it to a certain height. Calculate the height through which the load is lifted.

Ans :

Given, Work, $W = 4900 \text{ J}$

Mass, $m = 50 \text{ kg}$

Work done on road to lift = mgh

$$4900 = 50 \times 9.8 \times h$$

$$h = \frac{4900}{50 \times 9.8}$$

$$h = 10 \text{ m}$$

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- 126.** An engine work 54,000 J work by exerting a force of 6000 N on it. What is the displacement of the force?

Ans :

Given, $W = 54000 \text{ J}$

$F = 6000 \text{ N}$

$$S = \frac{W}{F} = \frac{54000 \text{ J}}{6000 \text{ N}} = 9 \text{ m}$$

- 127.** A body of mass 2 kg is moving with a speed of 20 m/s. Find the kinetic energy.

Ans :

Given, $m = 2 \text{ kg}$

$v = 20 \text{ m/s}$

$$\text{KE} = \frac{1}{2} mv^2$$

$$= \frac{1}{2} \times 2 \times 20 \times 20 = 400 \text{ J}$$

Average Power: 'Average power' signifies the total work done divided by the total time taken, especially when the rate of doing work is not constant. If an agent performs work at varying rates over a period, the average power gives an overall measure of its performance rate during that entire period. For example, if a machine's power output fluctuates, its average power provides a more meaningful measure over extended operation.

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- 119.** Describe different forms of energy. Can these forms be inter converted? Give two examples of energy inter conversion from daily life.

Ans :

Energy exists in many different forms. Some common forms include:

1. **Mechanical Energy:** The sum of potential energy (due to position or configuration) and kinetic energy (due to motion).
2. **Heat Energy (Thermal Energy):** Energy associated with the random motion of atoms and molecules; related to temperature.
3. **Chemical Energy:** Energy stored in the bonds of chemical compounds, released during chemical reactions (e.g., in food, fuels).
4. **Electrical Energy:** Energy associated with the flow of electric charge (electrons).
5. **Light Energy (Radiant Energy):** Energy that travels in the form of electromagnetic waves.
6. **Nuclear Energy:** Energy stored in the nucleus of an atom, released during nuclear reactions (fission or fusion).

Yes, these forms of energy can be inter converted from one form to another, adhering to the law of conservation of energy.

Examples of Energy Interconnection from Daily Life:

1. **Electric Bulb:** Electrical energy is converted into light energy and heat energy.
2. **Burning Wood (Chemical to Heat and Light):** The chemical energy stored in wood is converted into heat energy and light energy when it burns.
3. **Hydroelectric Power Plant:** Potential energy of stored water is converted into kinetic energy of flowing water, which then turns turbines (mechanical energy), and finally, a generator converts this mechanical energy into electrical energy.

- 120.** A freely falling object eventually stops on reaching the ground. What happens to its kinetic energy? Explain this in the context of energy conservation.

Ans :

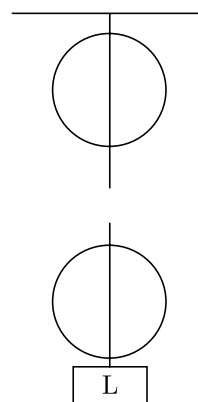
When a freely falling object is just about to reach the ground, it possesses maximum kinetic energy (as its potential energy has been converted into kinetic energy). Upon striking the ground, the object comes to rest, so its kinetic energy becomes zero.

This kinetic energy does not simply disappear; it is transformed into other forms of energy, consistent with the law of conservation of energy.

1. **Heat Energy:** A significant portion of the kinetic energy is converted into heat energy due to the impact with the ground and the deformation of both the object and the ground.
2. **Sound Energy:** The impact often produces sound, which is another form of energy.
3. **Deformation Energy (Work Done):** Some energy might be used to do work in deforming the object or the ground (e.g., creating a crater or dent).

So, the kinetic energy is dissipated as heat, sound, and work done in deformation, ensuring that the total energy of the system (object + ground + surroundings) remains conserved, even though the object's macroscopic kinetic energy becomes zero.

- 121.** Two pulleys are given as below.



- (a) Copy and complete the labelled diagram connecting the two pulleys with a tackle to obtain Velocity Ratio = 2.
- (b) If Load = 48 kgf and efficiency is 80% then calculate:
 1. Mechanical Advantage.
 2. Effort needed to lift the load.

Ans :

Kinetic Energy (E_k) is the energy possessed by an object due to its motion. Any moving object is capable of doing work.

Potential Energy (E_p) is the energy stored in an object by virtue of its position (e.g., gravitational potential energy due to height) or its configuration/shape (e.g., elastic potential energy in a stretched spring).

Derivation of Kinetic Energy:

Consider an object of mass 'm' initially at rest ($u = 0$). A constant force 'F' acts on it, producing an acceleration 'a' and causing it to attain a velocity 'v' after a displacement 's'.

Work done by the force, $W = F \times s$.

From Newton's second law, $F = ma$.

So, $W = (ma)s = mas$.

From the third equation of motion, $v^2 = u^2 + 2as$.

Since $u = 0$, $v^2 = 2as$, which means $as = \frac{v^2}{2}$.

Substituting this into the work equation:

$$W = m\left(\frac{v^2}{2}\right) = \frac{1}{2}mv^2.$$

This work done on the object to bring it from rest to velocity 'v' is stored as its kinetic energy.

Thus, the kinetic energy $E_k = \frac{1}{2}mv^2$.

Relationship (Work-Energy Theorem): The work done by the net force on an object is equal to the change in its kinetic energy. If an object's velocity changes from 'u' to 'v', the work done

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \Delta E_k.$$

- 117.** Explain the law of conservation of energy using the example of a simple pendulum oscillating freely. Discuss why the pendulum eventually comes to rest in a real-world scenario.

Ans :

The law of conservation of energy states that energy can neither be created nor destroyed, only transformed from one form to another; the total energy of an isolated system remains constant.

For a simple pendulum oscillating freely (ideal case, no air resistance or friction):

- 1. Extreme Position:** When the bob is at its highest point (extreme position), it momentarily stops. Here, its kinetic energy is zero, and its gravitational potential energy (relative to the mean position) is maximum.
- 2. Swinging Downwards:** As the bob swings towards its mean (lowest) position, its height decreases, so potential energy is converted

into kinetic energy. Its speed increases, reaching maximum at the mean position.

- 3. Mean Position:** At the mean position, potential energy is minimum (or zero), and kinetic energy is maximum.
- 4. Swinging Upwards:** As the bob swings towards the other extreme, kinetic energy is converted back into potential energy. Speed decreases, and potential energy increases. At any point in its oscillation, the sum of its kinetic energy and potential energy (total mechanical energy) remains constant. Why it eventually comes to rest in the real world:

In a real-world scenario, the pendulum eventually comes to rest due to:

Air Resistance: The bob experiences friction with the air as it moves, and work is done against this resistive force.

Friction at the Point of Suspension: There is friction at the pivot where the string is suspended. These resistive forces cause the mechanical energy of the pendulum to be gradually dissipated as heat energy into the surroundings. This does not violate the law of conservation of energy, as the mechanical energy is transformed into heat, but the total energy of the system (pendulum + surroundings) is still conserved.

- 118.** What is power? Define its SI unit. A body does 1200 J of work in 2 minutes. Calculate the power developed. What does 'average power' signify?

Ans :

Power is defined as the rate at which work is done or the rate at which energy is transferred or consumed. It measures how quickly work is performed.

The SI unit of power is the watt (W), named after James Watt. One watt is defined as the power when one joule of work is done in one second ($1 \text{ W} = 1 \text{ J/s}$).

Calculation:

Work done $W = 1200 \text{ J}$.

Time taken $t = 2 \text{ min ute}$

$$= 2 \times 60 \text{ seconds} = 120 \text{ s}.$$

Power developed

$$P = \frac{\text{Work done (W)}}{\text{Time taken (t)}}$$

$$= \frac{1200 \text{ J}}{120 \text{ s}}$$

$$= 10 \text{ J/s} = 10 \text{ W}.$$

The power developed is 10 watts.

- 128.** A moving body of 30 kg has 60 J of KE. Calculate the speed.

Ans :

$$\begin{aligned}\text{Given,} \quad \text{KE} &= \frac{1}{2} mv^2 \\ 60 &= 0.5 \times 30 \times v^2 \\ 60 &= 15 v^2 \\ v &= 2 \text{ m/s}\end{aligned}$$

- 129.** A hammer of mass 1 kg falls freely from a height of 2 m. Calculate (i) The velocity and (ii) The kinetic energy of the hammer just before it touches the ground. Does the velocity of hammer depend on the mass of hammer?

Ans :

$$\begin{aligned}\text{Given, Mass of hammer, } m &= 1 \text{ kg} \\ \text{Height, } h &= 2 \text{ m}\end{aligned}$$

As know that,

$$\begin{aligned}\text{PE} &= mgh = 1 \times 9.8 \times 2 \\ &= 19.6 \text{ J}\end{aligned}$$

$$\text{PE} = \text{KE} = \frac{1}{2} mv^2$$

$$19.6 = 0.5 \times 1 \times v^2$$

$$39.2 = v^2$$

$$v = 6.29 \text{ m/s}$$

No, velocity of hammer does not depend on the mass of the hammer as $v = u + at$

- 130.** Calculate the change that should be affected in the velocity of a body to maintain the same KE, if mass of the body is increased to 4 times.

Ans :

$$\text{Original KE} = \frac{1}{2} mv_1^2 \quad (1)$$

Now, if mass if increase 4 times then,

$$\text{New KE} = 4 \times \frac{1}{2} mv_2^2$$

$$\frac{1}{2} mv_1^2 = 4 \times \frac{1}{2} mv_2^2$$

$$v_1^2 = 4v_2^2$$

$$v_2 = \frac{v_1}{2}$$

Hence, new velocity will be bay the original velocity.

- 131.** A machine does 192 J of work in 24 sec. What is the power of the machine?

Ans :

$$\begin{aligned}\text{Given,} \quad W &= 192 \text{ J} \\ t &= 24 \text{ sec}\end{aligned}$$

As we know that,

$$P = \frac{W}{t} = \frac{192 \text{ J}}{24 \text{ sec}} = 8 \text{ W}$$

- 132.** A weight of 50 kg runs up a hill rising himself vertically 10 m in 20 sec. Calculate power. (Given $g = 9.8 \text{ ms}^{-1}$)

Ans :

$$\begin{aligned}\text{Given,} \quad P &= \frac{W}{t} = \frac{mgh}{t} \\ &= \frac{(50 \times 9.8 \times 10)}{20} = 245 \text{ W}\end{aligned}$$

- 133.** A rickshaw puller pulls the rickshaw by applying a force of 100 N. If the rickshaw moves with constant velocity of 36 kmh^{-1} . Find the power of rickshaw puller.

Ans :

$$\begin{aligned}\text{Given,} \quad \text{Force} &= 100 \text{ N} \\ \text{Velocity} &= 36 \text{ km/h} \\ &= \frac{36 \times 5}{18} = 10 \text{ m/s}\end{aligned}$$

As we know that,

$$\text{Power} = \text{Force} \times \text{Velocity}$$

$$\text{Power} = 100 \times 10 = 1000 \text{ Watt}$$

Therefore, power of rickshaw puller = 1000 Watt

- 134.** An athlete weighing 60 kg runs up a staircase having 10 steps each of 1 m in 30 sec. Calculate power ($g = 9.8 \text{ ms}^{-1}$).

Ans :

$$\text{Given, Height, } h = 10 \times 1 \text{ m} = 10 \text{ m}$$

$$\text{Work done} = \text{potential energy}$$

$$= mgh$$

$$= 60 \times 9.8 \times 10$$

$$= 5880 \text{ J}$$

$$\text{Power} = \frac{W}{t} = \frac{5880}{30} = 196 \text{ W}$$

- 135.** The heart does 1.5 J of work in each heartbeat. How many times per minute does it beat if its power is 2 watt?

Ans :

Given, Power, $p = 2$ Watt
 Time, $t = 1$ min.
 $= 1 \times 60 = 60$ sec.

Total work = $P \times t$
 $= 2 \times 60 = 120$ J,

Number times heartbeat in 1 min.

$$= \frac{\text{Total work done}}{\text{Work done in each beat}}$$

$$= \frac{120}{1.5} = 80 \text{ times}$$

- 136.** Calculate the time taken by 60 W bulb to consume 3000 J of energy.

Ans :

Given, Power = 60 W
 and Energy consumed = 3000 J
 We know that,

$$\text{Power} = \frac{\text{Energy}}{\text{Time Taken}}$$

$$\text{Time Taken} = \frac{\text{Energy Consumed}}{\text{Power}}$$

$$= \frac{3000}{60} = 50 \text{ sec}$$

- 137.** A horse exert a force of 200 N to pull the cart. If the horse cart system moves with velocity 36 kmh^{-1} on the level road, then find the power of horse in term of horse power ($1 \text{ HP} = 746 \text{ W}$).

Ans :

Given, Velocity = 36 kmh^{-1}
 $= 36 \times \frac{5}{18} = 10 \text{ m/s}$

As we know that,

$$W = F \times s = 200 \times 10$$

$$= 2000 \text{ J}$$

$$P = \frac{W}{t} = \frac{2000 \text{ J}}{1 \text{ sec}} = 2000 \text{ W}$$

$$746 \text{ W} = 1 \text{ HP}$$

So, $2000 \text{ W} = \frac{2000}{746} = 2.68 \text{ HP}$

- 138.** An electric kettle of 500W is used to heat water everyday for 2 hours. Calculate the number of unit of electrical energy consumed by it in 10 days.

Ans :

Given, $p = 500 \text{ W}$, Time, $t = 2 \text{ h}$
 Now, $E = Pt = 500 \text{ W} \times 10 \times 2\text{h}$
 $= 10000 \text{ Wh}$
 $= 10 \text{ kWh} = 10 \text{ unit}$

- 139.** Calculate the cost of using a 2 kWh immersion rod for heating water in a house for one hour each day for 60 days if the rate is 1.50 per unit kWh.

Ans :

Given, $p = 2 \text{ kwh}$
 As we know that,
 $E = Pt = 2 \text{ kW} \times 60 \times 1 \text{ h}$
 $= 120 \text{ kWh} = 120 \text{ unit}$

The cost of using a 2 kWh immersion rod for heating water = $120 \times 1.5 = ₹180$

- 140.** In an experiment to measure his power, a student records the time taken by him in running up a flight of steps on a staircase.

Ans :

Use the following data to calculate the power of the student :

$$\text{Number of steps} = 28,$$

$$\text{Height of each step} = 20 \text{ cm},$$

$$\text{Time taken} = 5.4 \text{ s},$$

$$\text{Mass of student} = 55 \text{ kg},$$

$$\text{Acceleration due to gravity} = 9.8 \text{ ms}^{-2}$$

$$\text{Power} = \frac{W}{t} = \frac{mgh}{t}$$

$$= \frac{55 \times 9.8 \times (28 \times 0.20)}{5.4}$$

$$= 558.96 \approx 559 \text{ J}$$

- 141.** A bullet of mass 15 g has a speed of 400 m/s. What is its kinetic energy? The bullet strikes a thick target and is brought to rest in 2 cm, calculate the average net force acting on the bullet. What happens to kinetic energy originally in the bullet?

Ans :

Given, Mass of bullet, $m = 15 \text{ g} = 0.015 \text{ kg}$
 Speed of bullet, $v = 400 \text{ m/s}$

As we know that,

$$\begin{aligned}\text{K.E.} &= \frac{1}{2}mv^2 \\ &= 0.5 \times 0.015 \text{ kg} \times (400 \times 400) \\ &= 1200 \text{ J.}\end{aligned}$$

Work done = Change in K.E.

As final velocity = 0

So, change in KE = $K_f - K_i = 1200 \text{ J}$

Therefore, $F \times d = 1200$
(where F is the average force.)

$$F = \frac{1200}{2 \times 10^{-2}} = 6 \times 10^4 \text{ N.}$$

The kinetic energy is eventually converted to heat energy.

- 142.** The power of a heart which beats 72 times in a minute is 1.2 kW. Calculate the work done by heart for each beat. (1 kJ)

Ans :

Given, $P = 1200 \text{ W}$ and $t = 60 \text{ s}$

$$W = P \times t = 1200 \times 60 = 72000 \text{ J}$$

In 72 times heartbeats 72000 J energy used

$$\text{In 1 beat} = \frac{72000}{72} = 1000 \text{ J}$$

Work done by the heart in every beat is 1 kJ.

- 143.** When loading a truck, a man lifts boxes of 100 N each through a height of 1.5 m.
- How much work does he do in lifting one box?
 - How much energy is transferred when one box is lifted?
 - If the man lifts 4 boxes per minute, at what power is he working? ($g = 10 \text{ m s}^{-2}$)

Ans :

(a) Work done in lifting one box

$$= F \times d = 100 \times 1.5 = 150 \text{ J.}$$

(b) $W = E = 150 \text{ J.}$

(c) $\text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{150 \times 4}{60} = 10 \text{ W}$

- 144.** Calculate the electricity bill amount for a month of 31 days, if the following devices are used as specified.

(a) 3 bulbs of 40 W for 6 hours.

(b) 4 tubelights of 50 W for 8 hours,

(c) A TV of 120 W for 6 hours.

The rate of electricity is ₹2.50 per unit.

Ans :

$$\begin{aligned}\text{(a)} \quad E_1 &= P \times t = 0.04 \times 6 \times 3 \\ &= 0.72 \text{ kWh}\end{aligned}$$

$$\begin{aligned}\text{(b)} \quad E_2 &= P \times t = 0.05 \times 8 \times 4 \\ &= 1.60 \text{ kWh}\end{aligned}$$

$$\text{(c)} \quad E_3 = 0.12 \times 6 = 0.72 \text{ kWh}$$

$$\text{Total E} = 0.72 + 1.6 + 0.72 = 3.04 \text{ kWh}$$

$$\begin{aligned}\text{Cost in 31 days} &= \text{rate} \times \text{E} \\ &= 3.04 \times 2.50 \times 31 = \text{₹}235.60\end{aligned}$$

- 145.** (a) What is meant by mechanical energy? State its two forms. State the law of conservation of energy. Give an example in which we observe a continuous change of one form of energy into another and vice-versa.
- (b) Calculate the amount of work required to stop a car of 1000 kg moving with a speed of 72 km/h.

Ans :

- (a) Mechanical energy is the sum of kinetic energy and potential energy of an object. It states that energy can neither be created nor be destroyed. We observe a continuous change in energy in a simple pendulum. At the mean position, the energy is totally kinetic while at the extreme position it is totally potential. As the pendulum oscillates its energy continuously changes between kinetic and potential.

(b) Given, mass, $m = 1000 \text{ kg}$

Initial velocity, $u = 72 \text{ kmh}^{-1}$

$$= 72 \times \frac{5}{18} = 20 \text{ ms}^{-1},$$

Final velocity, $v = 0$

Work done = change in kinetic energy

$$= \frac{1}{2}m(v^2 - u^2)$$

$$= \frac{1}{2} \times 1000 \times (0^2 - 20^2)$$

$$= -200000 \text{ J} = -2 \times 10^5 \text{ J}$$

- 146.** (a) State the law of conservation of energy.
- (b) What is the work done to increase the velocity of a car from 36 km h^{-1} to 72 kmh^{-1} if the mass of the car is 1500 kg? Does the work done by the force have a negative or a positive magnitude?

Since $u = 0$
 $v^2 = 2as$.

Rearranging this,
 $as = \frac{v^2}{2}$.

Substitute this value of 'as' into the work equation:

$$W = m\left(\frac{v^2}{2}\right)$$

$$= \frac{1}{2}mv^2$$

The initial kinetic energy (E_{ki}) was $\frac{1}{2}mu^2 = 0$ (since $u = 0$).

The final kinetic energy (E_{kf}) is $\frac{1}{2}mv^2$.

Change in kinetic energy

$$= E_{kf} - E_{ki}$$

$$= \frac{1}{2}mv^2 - 0 = \frac{1}{2}mv^2$$

Thus, work done $W = \frac{1}{2}mv^2$, which is equal to the change in its kinetic energy. This is known as the work-energy theorem.

- 160.** An object of mass 15 kg is moving with a uniform velocity of 4 m/s. What is the kinetic energy possessed by the object? If its velocity is doubled, what will be its new kinetic energy?

Ans :

Given, Mass $m = 15\text{kg}$, Velocity $v = 4\text{m/s}$.

Kinetic energy

$$E_k = \frac{1}{2}mv^2$$

$$= \frac{1}{2} \times 15\text{kg} \times (4\text{m/s})^2$$

$$= \frac{1}{2} \times 15 \times 16\text{J}$$

$$= 15 \times 8\text{J} = 120\text{J}.$$

If its velocity is doubled, new velocity

$$v' = 2 \times 4\text{m/s}$$

$$= 8\text{m/s}.$$

New kinetic energy

$$E_k' = \frac{1}{2}mv'^2$$

$$= \frac{1}{2} \times 15\text{kg} \times (8\text{m/s})^2$$

$$= \frac{1}{2} \times 15 \times 64\text{J}$$

$$= 15 \times 32\text{J} = 480\text{J}.$$

The new kinetic energy will be 480 J (which is four times the original KE).

- 161.** The kinetic energy of an object of mass 'm' moving with a velocity of 5 m/s is 25 J.
 (a) What is the mass 'm' of the object?
 (b) What will be its kinetic energy when its velocity is increased three times?

Ans :

Given, Velocity $v = 5\text{m/s}$, Kinetic energy $E_k = 25\text{J}$.

(a) $E_k = \frac{1}{2}mv^2$

$$25\text{J} = \frac{1}{2} \times m \times (5\text{m/s})^2$$

$$25 = \frac{1}{2} \times m \times 25$$

$$25 = 12.5m$$

$$m = \frac{25}{12.5} = 2\text{kg}.$$

The mass of the object is 2 kg.

- (b) If velocity is increased three times, new velocity

$$v' = 3 \times 5\text{m/s} = 15\text{m/s}.$$

New kinetic energy

$$E_k' = \frac{1}{2}mv'^2$$

$$= \frac{1}{2} \times 2\text{kg} \times (15\text{m/s})^2$$

$$= 1 \times 225\text{J} = 225\text{J}.$$

Its kinetic energy will be 225 J.

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- 162.** An object of mass 12 kg is at a certain height above the ground. If the potential energy of the object is 480 J, find the height at which the object is with respect to the ground. (Given, $g = 10\text{m/s}^2$).

Ans :

Given, Mass $m = 12\text{kg}$,

Potential energy $E_p = 480\text{J}$,

Acceleration due to gravity $g = 10\text{m/s}^2$.

The formula for potential energy is $E_p = mgh$.

We need to find the height 'h'.

$$480\text{J} = 12\text{kg} \times 10\text{m/s}^2 \times h$$

$$480 = 120h$$

$$h = \frac{480}{120}\text{m} = 4\text{m}.$$

The object is at a height of 4 meters with respect to the ground.

- 153.** Calculate the work done in lifting 200 kg of water through a vertical height of 6 m.

Ans :

- (i) Work done in lifting a body

$$= \text{Weight of body} \times \text{vertical distance}$$
 (ii) The work done in lifting

$$= W = mgh$$

$$= 200 \text{ kg} \times 10 \text{ m/s}^2 \times 6 \text{ m} = 1200 \text{ J}$$

- 154.** What is the work done by the force of gravity in the following cases?

- (a) Satellite moving around the Earth in a circular orbit of radius 35000 km.
 (b) A stone of mass 250 g is thrown up through a height of 2.5 m.

Ans :

- (a) Zero, as the displacement in one complete revolution is zero.
 (b) Given $m = 250 \text{ g} = 0.25 \text{ kg}$, $h = 2.5 \text{ m}$, $g = 10 \text{ ms}^{-2}$, $W = ?$

$$\begin{aligned} \text{Now, } W &= Fs = mg \times h \\ &= 0.25 \times 10 \times 2.5 = 6.25 \text{ J} \end{aligned}$$

- 155.** An object of mass when raised to height h possess a potential energy of 1200 J. Find the new potential energy :

- (a) if the same object is raised to height $\frac{h}{4}$.
 (b) if the same object is raised to height $4h$.

Ans :

$$\text{PE} = 1200 \text{ joules}$$

$$\begin{aligned} \text{(a) New } \text{PE} &= \frac{1}{4} \text{ old PE} \\ &= \frac{1}{4} \times 1200 = 300 \text{ joules} \end{aligned}$$

$$\begin{aligned} \text{(b) New } \text{PE} &= 4 \times \text{old PE} \\ &= 4 \times 1200 = 4800 \text{ joules} \end{aligned}$$

- 156.** Define 1 watt of power. A lamp consumes 1000 J of electrical energy in 10 s. Calculate its power.

Ans :

The power of an agent is said to be one watt if it does one joule of work in one second.

- (a) Given $W = 1000 \text{ J}$, $t = 10 \text{ s}$, $P = ?$
 (b) Using the expression,

$$P = \frac{W}{t},$$

$$\text{We have } P = \frac{1000}{10} = 100 \text{ W}$$

- 157.** An electric lamp consumes 1000 J of electrical energy in 10 s. What is its power?

Ans :

Power (P) is the rate of energy consumption, given by $P = \text{Energy consumed (W or E)} / \text{time taken (t)}$.

Energy consumed $E = 1000 \text{ J}$.

Time taken $t = 10 \text{ s}$.

$$\begin{aligned} \text{Power } P &= \frac{1000 \text{ J}}{10 \text{ s}} \\ &= 100 \text{ J/s} = 100 \text{ watts (W)}. \end{aligned}$$

The power of the lamp is 100 watts.

- 158.** Two objects have the same mass but different velocities (v and $2v$). What is the ratio of their kinetic energies?

Ans :

Kinetic energy $E_k = \frac{1}{2}mv^2$.

For the first object, $E_{k1} = \frac{1}{2}mv^2$.

For the second object,

$$\begin{aligned} E_{k2} &= \frac{1}{2}m(2v)^2 \\ &= \frac{1}{2}m(4v^2) \\ &= 4 \times \left(\frac{1}{2}mv^2\right) \\ &= 4E_{k1}. \end{aligned}$$

The ratio of their kinetic energies ($E_{k1}:E_{k2}$) is 1:4.

- 159.** An object of mass 'm' starts from rest and attains a velocity 'v' after a constant force 'F' acts on it, causing a displacement 's'. Show that the work done on the object is equal to the change in its kinetic energy.

Ans :

Let an object of mass 'm' be initially at rest (initial velocity $u = 0$). A constant force 'F' acts on it, producing an acceleration 'a' and causing a displacement 's', and its final velocity becomes 'v'.

Work done by the force, $W = F \times s$.

According to Newton's second law, $F = ma$.

So, $W = (ma)s = mas$.

From the third equation of motion,

$$v^2 = u^2 + 2as.$$

- (c) Where does an oscillating pendulum have maximum PE and RE?

Ans :

- (a) It states that energy can neither be created nor be destroyed.

- (b) Given,

$$m = 1500 \text{ kg},$$

$$u = 36 \text{ kmh}^{-1} = 36 \times \frac{5}{18} = 10 \text{ ms}^{-1},$$

$$v = 72 \text{ kmh}^{-1} = 72 \times \frac{5}{18} = 20 \text{ ms}^{-1}, W = ?$$

Work done = change in kinetic energy

$$\begin{aligned} &= \frac{1}{2}mv^2 - \frac{1}{2}mu^2 \\ &= \frac{1}{2}m(v^2 - u^2) \\ &= \frac{1}{2} \times 1500 \times [(20)^2 - (10)^2] \\ &= \frac{1}{2} \times 1500 [400 - 100] \\ &= \frac{1}{2} \times 1500 \times 300 \\ &= 225000 \text{ J} \end{aligned}$$

The work done is positive.

- (c) It has maximum potential energy at its extreme position and maximum kinetic energy at the mean position.

147. Find the energy in kWh consumed in 10 hours by a machine of power 500 W.

Ans :

Given, Power, $p = 500 \text{ W}$

Time, $t = 10 \text{ h}$

As we know that

$$\begin{aligned} W &= P \times t \\ &= 500 \times 10 \\ &= 5000 \text{ Wh} \\ &= 5 \text{ kWh.} \end{aligned}$$

148. A force of 7 N acts on an object. The displacement is, say 8 m, in the direction of the force. Let us take it that the force acts on the object through the displacement. What is the work done in this case?

Ans :

Given, Displacement = 8 m,

Force = 7 N

As we know that,

Now, Work done = Force $\times$ Displacement
 $= 7 \times 8 = 56 \text{ J}$

149. A lamp consumes 1000 J of electrical energy in 10 s. What is its power?

Ans :

Given, $W = 1000 \text{ J}, t = 10 \text{ s}, P = ?$

Using $P = \frac{W}{t} = \frac{1000}{10} = 100 \text{ W}$

150. The potential energy of a body is 39600 J. How high is the body if its mass is 20 kg?

Ans :

Given, P.E. = 39600 J

Mass of body, $m = 20 \text{ kg}$

As we know that

The potential energy of a body = mgh

$$\begin{aligned} h &= \frac{\text{P.E.}}{mg} \\ &= \frac{39600 \text{ J}}{20 \text{ kg} \times 10 \text{ m/s}^2} = 198 \text{ m} \end{aligned}$$

151. How much work is done by a force of 10 N in moving an object through a distance of 4 m in the direction of the force?

Ans :

Given, Force, $F = 10 \text{ N}$

Displacement, $s = 4 \text{ m}$

We know that

$$\begin{aligned} \text{Work done} &= \text{Force} \times \text{Displacement} \\ &= F \times s \\ &= (10 \text{ N}) \times (4 \text{ m}) \\ &= 40 \text{ joule or } 40 \text{ J.} \end{aligned}$$

152. A rocket is moving up with a velocity v . If the velocity of this rocket is suddenly tripled, what will be the ratio of two kinetic energies?

Ans :

$$\begin{aligned} \frac{\text{Initial KE}}{\text{Final KE}} &= \frac{\left(\frac{1}{2}mv^2\right)}{\left(\frac{1}{2}m(3v)^2\right)} = \frac{\left(\frac{1}{2}mv^2\right)}{\left\{\frac{1}{2}m(3v)^2\right\}} \\ &= 1 : 9 \end{aligned}$$

- 163.** Two girls, each of weight 400 N, climb up a rope through a height of 8 m. Girl A takes 20 s while Girl B takes 50 s to accomplish this task. What is the power expended by each girl?

Ans :

Work done by each girl (W)

$$= \text{Force (weight)} \times \text{displacement (height)}$$

$$= mgh.$$

Given weight $mg = 400\text{N}$, height $h = 8\text{m}$.

Work done $W = 400\text{N} \times 8\text{m}$

$$= 3200\text{J}.$$

Power expended by Girl A (P_A): Time taken $t_A = 20\text{s}$.

$$\begin{aligned} P_A &= \frac{W}{t_A} \\ &= \frac{3200\text{J}}{20\text{s}} = 160\text{W}. \end{aligned}$$

Power expended by Girl B (P_B): Time taken $t_B = 50\text{s}$.

$$\begin{aligned} P_B &= \frac{W}{t_B} \\ &= \frac{3200\text{J}}{50\text{s}} = 64\text{W}. \end{aligned}$$

Girl A expended 160 watts, and Girl B expended 64 watts.

- 164.** A pair of bullocks exerts a force of 140 N on a plough. The field being ploughed is 15 m long. How much work is done in ploughing the length of the field once?

Ans :

Given, Force exerted by the bullocks $F = 140\text{ N}$.
Length of the field (displacement in the direction of force) $s = 15\text{ m}$.

Work done (W) in ploughing the length of the field is given by

$$\begin{aligned} W &= \text{Force} \times \text{displacement} \\ &= 140\text{N} \times 15\text{m}. \\ &= 2100\text{Nm}. \end{aligned}$$

Therefore, 2100 Joules of work is done in ploughing the length of the field once.

- 165.** What is the work to be done to increase the velocity of a car from 30 km/h to 60 km/h if the mass of the car is 1500 kg?

Ans :

Mass $m = 1500\text{kg}$.

Initial velocity

$$u = 30\text{km/h}$$

$$= 30 \times \frac{1000}{3600}\text{m/s}$$

$$= 30 \times \frac{5}{18}\text{m/s}$$

$$= \frac{150}{18}\text{m/s} = \frac{25}{3}\text{m/s}.$$

Final velocity

$$v = 60\text{km/h}$$

$$= 60 \times \frac{5}{18}\text{m/s}$$

$$= \frac{300}{18}\text{m/s} = \frac{50}{3}\text{m/s}.$$

Work done = Change in kinetic energy

$$= E_{kf} - E_{ki}$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$= \frac{1}{2}m(v^2 - u^2).$$

$$v^2 - u^2 = \left(\frac{50}{3}\right)^2 - \left(\frac{25}{3}\right)^2$$

$$= \frac{2500}{9} - \frac{625}{9}$$

$$= \frac{1875}{9} = \frac{625}{3}.$$

$$\text{Work done} = \frac{1}{2} \times 1500 \times \left(\frac{625}{3}\right)$$

$$= 750 \times \frac{625}{3}$$

$$= 250 \times 625 = 156250\text{J}.$$

The work to be done is 156,250 Joules.

- 166.** A lamp consumes 1000 J of electrical energy in 10 s. What is its power? An electric heater is rated 1500 W. How much energy does it use in 10 hours?

Ans :

For the lamp: Energy consumed $E = 1000\text{ J}$, Time $t = 10\text{ s}$.

$$\begin{aligned} \text{Power} \quad P &= \frac{E}{t} \\ &= \frac{1000\text{J}}{10\text{s}} = 100\text{W}. \end{aligned}$$

For the electric heater:

Power $P = 1500\text{ W} = 1.5\text{ kW}$.

Time $t = 10\text{ hours}$.

Energy consumed

$$E = P \times t$$

$$E = 1500\text{W} \times 10\text{hours} \times 3600\text{s/hour}$$

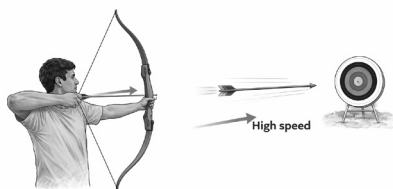
(to get Joules)

- (e) Differentiate between the type of potential energy in the stretched bow and the arrow placed high in the quiver.

Ans :

- Elastic potential energy is stored in the stretched bow.
- The bow acquires this energy because the trainer does work on it by applying muscular force to deform its original shape. This work is stored internally as potential energy due to its new configuration.
- When the string is released, the bow rapidly returns to its original shape. The stored elastic potential energy of the bow is transferred to the arrow, converting into kinetic energy, which causes the arrow to fly forward.
- Gravitational Potential Energy = $mgh = 0.05 \text{ kg} \times 10 \text{ m/s}^2 \times 2 \text{ m} = 1 \text{ J}$.
- The stretched bow possesses potential energy due to its deformed shape or configuration (elastic potential energy). In contrast, the arrow in the quiver possesses potential energy due to its elevated position or height relative to the surface of the Earth (gravitational potential energy).

- 183.** An archer pulls back the string of a bow, placing an arrow against it. When the string is released, the arrow flies off at a high speed towards the target.



- When the archer pulls back the bowstring, what kind of energy is stored in the stretched bow?
- What happens to this stored energy when the bowstring is released?
- What kind of energy does the arrow possess as it flies towards the target?
- If the archer stretches the bowstring further back (more displacement), how does this affect the energy stored and the subsequent speed of the arrow (assuming arrow mass is constant)?

Ans :

- When the archer pulls back the bowstring, potential energy (specifically, elastic potential energy) is stored in the stretched bow.
- When the bowstring is released, the stored potential energy in the bow is converted into kinetic energy of the arrow.
- As the arrow flies towards the target, it possesses kinetic energy due to its motion.
- Stretching the bowstring further back increases the potential energy stored in the bow. This increased potential energy will be converted into greater kinetic energy for the arrow, resulting in a higher speed for the arrow.

184. A group of friends visits an amusement park and stands in awe watching a massive steel roller coaster. The empty coaster cars are slowly mechanically pulled up a steep incline to the highest peak of the ride, Point X, which is situated exactly 50 metres above the ground. At this peak, the cars briefly pause before plunging rapidly down a terrifying steep drop to Point Y, located just 5 metres above the ground. As the cars speed through the bottom track at their maximum velocity, the riders experience a thrilling rush. (Assume air resistance and track friction are completely negligible for this scenario).

QUESTIONS:

- What is mechanical energy defined as?
- At Point X, what is the primary form of mechanical energy possessed by the roller coaster cars?
- Based on energy conversion, explain why the speed of the roller coaster increases drastically as it moves downwards from Point X to Point Y.
- If friction and air resistance are completely ignored, what happens to the total mechanical energy of the coaster during the steep drop? State the principle that supports this.

Ans :

- Mechanical energy is defined as the sum of the kinetic energy and the potential energy of an object.
- At Point X (the highest point where the cars briefly pause), the roller coaster possesses maximum gravitational potential energy and zero kinetic energy.

To convert seconds to hours:

Number of hours

$$= \frac{1,800,000\text{s}}{3600\text{s/hour}}$$

$$= \frac{18000}{36}\text{hours} = 500\text{hours}.$$

The appliance was used for 500 hours.

- 169.** Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h.

Ans :

Mass of the car $m = 1500\text{kg}$.

Initial velocity of the car $u = 60\text{km/h}$.

First, convert the velocity to m/s:

$$u = 60\text{km/h}$$

$$= 60 \times \frac{1000\text{m}}{3600\text{s}}$$

$$= 60 \times \frac{5}{18}\text{m/s}$$

$$= \frac{300}{18}\text{m/s} = \frac{50}{3}\text{m/s}$$

$$\approx 16.67\text{m/s}.$$

To stop the car, its final velocity $v = 0\text{m/s}$.

The work required to stop the car is equal to the change in its kinetic energy (Work-Energy Theorem).

Initial kinetic energy

$$E_{ki} = \frac{1}{2}mu^2$$

$$= \frac{1}{2} \times 1500\text{kg} \times \left(\frac{50}{3}\text{m/s}\right)^2$$

$$= \frac{1}{2} \times 1500 \times \frac{2500}{9}\text{J}$$

$$= 750 \times \frac{2500}{9}\text{J}$$

$$= \frac{1875000}{9}\text{J} \approx 208333.33\text{J}.$$

Final kinetic energy

$$E_{kf} = \frac{1}{2}mv^2$$

$$= \frac{1}{2} \times 1500 \times (0)^2 = 0\text{J}.$$

Work done $W = E_{kf} - E_{ki}$

$$= 0 - 208333.33\text{J} = -208333.33\text{J}$$

The work required to be done on the car is -208333.33J . The negative sign indicates that the force doing this work (braking force) acts opposite to the car's motion. The magnitude of work required is $208,333.33\text{Joules}$.

- 170.** Four devices of power 500 W each are operated for 10 hours. Find the total energy consumed by these devices in joules and in commercial units (kWh).

Ans :

Given,

Power of one device $P_1 = 500\text{W}$.

Number of devices = 4.

Total power of all devices

$$P_{total} = 4 \times 500\text{W} = 2000\text{W}.$$

Time of operation $t = 10\text{hours}$.

Energy consumed in commercial units (kWh):

First, convert total power to kilowatts:

$$P_{total} = 2000\text{W} = 2\text{kW}.$$

Energy consumed (E) = Total Power $\times$ Time

$$E = 2\text{kW} \times 10\text{h}$$

$$= 20\text{kWh}.$$

The total energy consumed is 20 commercial units (kWh).

Energy consumed in joules:

We know $1\text{ kWh} = 3.6 \times 10^6\text{J}$.

So, $E = 20\text{kWh} \times 3.6 \times 10^6\text{J/kWh}$

$$= 72 \times 10^6\text{J} = 7.2 \times 10^7\text{J}.$$

Alternatively, using power in watts and time in seconds:

Time $t = 10\text{hours}$

$$= 10 \times 3600\text{seconds} = 36000\text{s}.$$

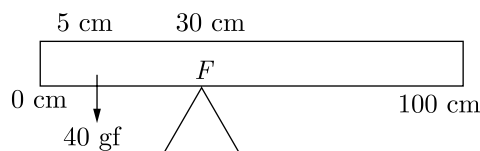
$$E = P_{total} \times t$$

$$= 2000\text{W} \times 36000\text{s}$$

$$= 72,000,000\text{J} = 7.2 \times 10^7\text{J}.$$

The total energy consumed is $7.2 \times 10^7\text{ joules}$.

- 171.** A uniform metre scale is in equilibrium as shown in the diagram :



- (i) Calculate the weight of the metre scale.
 (ii) Which of the following options is correct to keep the ruler in equilibrium when 40 gf wt is shifted to 0 cm mark?
 F is shifted towards 0 cm or
 F is shifted towards 100 cm.

are perpendicular to each other, no work is done by that force.

- 178.** A student, Rohan, spends 10 minutes pushing against a stationary brick wall with all his might. He feels very tired afterwards and believes he has done a lot of work. However, the wall does not move at all.



1. According to the scientific definition of work, has Rohan done any work on the wall? Explain why or why not.
2. What two conditions must be satisfied for work to be done on an object?
3. Even though no scientific work was done on the wall, Rohan felt tired. Where did the energy he expended go?
4. If Rohan had pushed a small toy car with the same force and it moved a distance of 2 meters, would work have been done on the toy car?

Ans :

1. No, according to the scientific definition of work, Rohan has not done any work on the wall. Work is done when a force causes displacement of an object in the direction of the force. Since the wall did not move (no displacement), no work was done on it.
2. The two conditions are: (i) a force should act on an object, and (ii) the object must be displaced.
3. The energy Rohan expended was converted into heat within his own body due to muscular effort (internal energy changes, metabolic processes).
4. Yes, if Rohan pushed a toy car and it moved, work would have been done on the toy car because there was a force applied and a displacement in the direction of the force.

- 179.** During a crucial inter-school football tournament, Rahul, a star striker, receives a pass near the penalty area. He aggressively kicks the stationary ball straight towards the opponent's goalpost. The ball speeds up rapidly and moves in the exact direction of his powerful kick. Seeing the impending danger, the opposing goalkeeper, Kabir, anticipates the trajectory. He dives elegantly and applies a strong force with his extended hands to stop the ball from entering the net. The momentum of the ball pushes Kabir's hands slightly backward by 0.2 metres before the ball finally comes to a complete halt in his firm grip.

QUESTIONS:

- (a) State the type of work done by Rahul when he kicks the stationary football.
- (b) Explain why the work done by the goalkeeper, Kabir, on the moving ball is considered negative work.
- (c) If Kabir applied a stopping force of 250 N and his hands moved back by 0.2 m in the direction of the ball's motion, calculate the work done by him on the ball.

Ans :

- (a) Rahul does positive work on the football because the force he applies and the resulting displacement of the ball are in the same direction.
- (b) Kabir applies a force in the opposite direction to the ball's motion to stop it. When the applied force and the displacement of the object are in opposite directions, the work done is negative.
- (c) Work done = Force $\times$ displacement in the direction of force. Since Kabir's force is opposite to the displacement, $W = 250 \text{ N} \times (-0.2 \text{ m}) = -50 \text{ J}$.

- 180.** In a spacious physics laboratory, a group of students is studying the principles of motion using two battery-operated toy cars, labeled Car A and Car B. Car A has a mass of 2 kg, while Car B is considerably heavier, with a mass of 4 kg. Initially, both cars are programmed to move side-by-side on a straight racing track at a constant velocity of 3 m/s. After recording their initial observations, the students modify the settings to increase the speed of Car A from 3 m/s to 6 m/s to investigate how a change in velocity mathematically impacts the energy possessed by a moving vehicle.

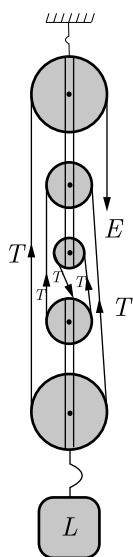
- (b) Rohan exerts a pull of 150 kgf. What is the maximum load he can raise with this pulley system if its efficiency = 75% ?

Ans :

COMP 2015

Diagram V.R. = 5

(a)



Block and Tackle system

(b)

$$VR = 5,$$

$$\text{Effort} = 150 \text{ kg f},$$

$$\text{Load} = ?,$$

$$\text{Efficiency} = 75\%$$

$$\text{Efficiency} = \frac{MA}{VR}$$

$$MA = VR \times \text{Efficiency}$$

$$= 5 \times \frac{75}{100} = 3.75$$

$$\text{Load} = MA \times \text{Effort}$$

$$= 3.75 \times 150 \text{ kg f}$$

$$= 562.50 \text{ kgf}$$

176. A fulcrum divides a crowbar in the ratio 3 : 1. What weight will be lifted if an effort of 100 N is applied at the end of its longer arm?

Ans :

As we know that the ratio of the effort arm and load arm is

Effort arm: Load arm = 3:1,

Given, Effort = 100 N, Load = ?

$$\frac{\text{Load}}{\text{Effort}} = \frac{\text{Effort arm}}{\text{Load arm}}$$

$$\frac{\text{Load}}{100 \text{ N}} = \frac{3}{1} \Rightarrow \text{Load} = 300 \text{ N}$$

CASE BASED QUESTIONS

177. Amit is trying to rearrange his bedroom on a Sunday afternoon. First, he pushes a heavy vintage wooden wardrobe with a force of 150 N, but the wardrobe stubbornly refuses to move. Frustrated, he shifts his attention and pushes a lighter study chair with a 50 N force, successfully moving it by 2 metres across the floor in a straight line. Later, he lifts a 5 kg pile of heavy encyclopaedias and holds them perfectly steady on his head for three minutes while deciding where to place them on the shelf. Finally, balancing the books on his head, he walks horizontally across the room to reach the bookshelf.

QUESTIONS:

- How much work is done by Amit when he applies a 150 N force to push the heavy wooden wardrobe?
- Calculate the work done by Amit on the study chair.
- Explain why Amit does zero work while holding the heavy pile of books steady on his head, even though he might feel tired.
- State the amount of work done by Amit against gravity when he walks horizontally across the room with the books on his head. Justify your answer.

Ans :

- The work done by Amit is zero because the displacement of the heavy wooden wardrobe is zero.
- Work done on the chair

$$= \text{Force} \times \text{displacement.}$$

$$= 50 \text{ N} \times 2 \text{ m} = 100 \text{ J.}$$
- Amit does zero work on the books while holding them steady because there is no displacement. He feels tired because his muscles continuously consume internal bodily energy to maintain the upward force balancing gravity.
- The work done against gravity is zero. This is because the gravitational force acts downwards, while Amit's displacement is horizontal. Since the force and displacement

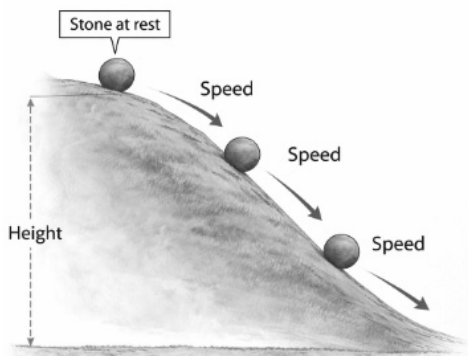
According to the theorem, Work done = Change in kinetic energy = $-200,000 \text{ J}$. The negative sign indicates that the work is done in a direction opposite to the car's motion, thereby removing energy from the car.

$$\begin{aligned} \text{(d) Work} &= \text{Force} \times \text{displacement. } -200,000 \text{ J} \\ &= \text{Force} \times 40 \text{ m.} \end{aligned}$$

$$\text{Force} = -200,000/40 = -5,000 \text{ N.}$$

The magnitude of the braking force is $5,000 \text{ N}$.

- 187.** A stone is at rest at the top of a hill. It then starts rolling down the hill. As it rolls down, its speed increases, and its height above the ground decreases. (Neglect friction).



- What type(s) of mechanical energy does the stone possess when it is at rest at the top of the hill?
- As the stone rolls down, what energy transformation takes place?
- At the bottom of the hill (ground level), what type(s) of mechanical energy does the stone primarily possess if it's still moving?
- If there was significant friction as the stone rolled down, how would this affect the total mechanical energy (sum of potential and kinetic) of the stone? Would the law of conservation of energy still hold?

Ans :

- When at rest at the top of the hill, the stone possesses gravitational potential energy. Its kinetic energy is zero.
- As the stone rolls down, its potential energy is converted into kinetic energy.
- At the bottom of the hill, if it's still moving, it primarily possesses kinetic energy (its potential energy relative to the ground level would be zero or minimal).

- If there was significant friction, some of the mechanical energy (potential and kinetic) would be converted into heat energy due to work done against friction. The total mechanical energy of the stone would decrease. However, the law of conservation of energy would still hold if all forms of energy (including heat) are considered; the total energy of the system (stone + surroundings) would remain constant.

- 188.** Two farmers, Ram and Shyam, are tasked with pumping water from a deep community well to irrigate their respective agricultural fields. Both farmers need to lift exactly 2000 kg of water to an overhead tank situated at a vertical height of 10 metres . Ram uses an older, traditional diesel-powered water pump, which operates loudly and completes the task in 100 seconds . On the other hand, Shyam recently purchased a modern, highly efficient electric water pump that runs quietly and completes the exact same water-lifting task in just 40 seconds . (Assume acceleration due to gravity, $g = 10 \text{ m/s}^2$).

QUESTIONS:

- Define power and state its SI unit.
- Into which form of energy is electrical energy primarily converted by Shyam's water pump to lift the water?
- Did Shyam's electric pump do more work than Ram's diesel pump? Explain your answer.
- Calculate the exact amount of work done by either pump to lift the water to the tank.
- Calculate and compare the power developed by Ram's diesel pump and Shyam's electric pump.

Ans :

- Power is defined as the rate at which work is done. Its SI unit is the watt (W).
- The electrical energy is primarily converted into mechanical energy (specifically, the gravitational potential energy of the lifted water).
- No, both pumps did the exact same amount of work. This is because work depends on force and displacement, and both pumps lifted the same mass of water (2000 kg) to the same height (10 m).

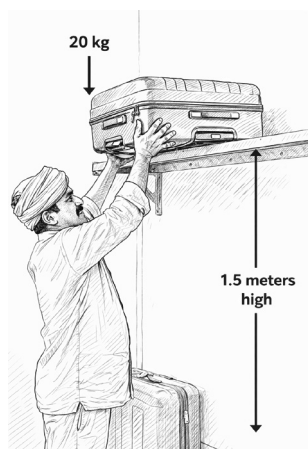
QUESTIONS:

- Define the term kinetic energy based on your understanding of the chapter.
- While both cars are moving at the initial velocity of 3 m/s, which car possesses more kinetic energy? Give a reason for your choice.
- Calculate how many times the kinetic energy of Car A increases when its velocity is doubled from 3 m/s to 6 m/s. Show your reasoning.

Ans :

- Kinetic energy is the energy possessed by an object due to its motion.
- Car B possesses more kinetic energy. Since kinetic energy is directly proportional to mass ($K = \frac{1}{2}mv^2$), for objects moving at the same velocity, the object with the greater mass will have higher kinetic energy.
- The kinetic energy increases by 4 times. Kinetic energy is directly proportional to the square of the velocity (v^2). When the velocity is doubled ($2v$), the square of the velocity becomes $(2v)^2 = 4v^2$, thus making the new kinetic energy four times the original value.

- 181.** A porter lifts a suitcase weighing 20 kg from the ground and places it on a shelf 1.5 meters high. (Assume acceleration due to gravity, $g = 10\text{m/s}^2$).



- What is the minimum force the porter must apply to lift the suitcase upwards (equal to its weight)?
- Calculate the work done by the porter on the suitcase.
- If the porter then carries the suitcase horizontally for 5 meters without changing its height, how much work is done by the porter against gravity during this horizontal movement?

- What form of energy does the suitcase gain when it is lifted to the shelf?

Ans :

- The minimum force the porter must apply is equal to the weight of the suitcase:

$$\begin{aligned}\text{Force} &= \text{mass} \times g \\ &= 20\text{kg} \times 10\text{m/s}^2 = 200\text{N}.\end{aligned}$$

- Work done

$$\begin{aligned}(W) &= \text{Force (F)} \times \text{displacement (s)} \\ &= 200\text{N} \times 1.5\text{m} = 300\text{J}.\end{aligned}$$

- During the horizontal movement, the displacement is horizontal, while the force of gravity acts vertically downwards. Since the force against which work is being considered (gravity) is perpendicular to the displacement, the work done by the porter against gravity is zero during this horizontal movement. (Note: Work is done against friction if the porter is accelerating the suitcase horizontally, but the question specifies work against gravity).
- The suitcase gains gravitational potential energy.

- 182.** Neha visits a local archery training centre during her summer vacation. She keenly observes an expert trainer demonstrating the correct technique to shoot an arrow. The trainer pulls the string of the flexible bow tightly backward, significantly changing its shape. He holds it there motionless for a few seconds, carefully aiming at the bullseye. When he releases the string, the arrow shoots forward at an incredibly high speed. After the practice session concludes, the trainer picks up a dropped 0.05 kg arrow from the floor and places it securely back into a wall-mounted quiver located exactly 2 metres above the ground.

QUESTIONS:

- Name the specific type of energy stored in the bow when the string is pulled tightly backward.
- How does the stretched bow acquire this stored energy?
- Describe the energy transformation that takes place the moment the trainer releases the stretched bowstring.
- Calculate the potential energy gained by the arrow when the trainer lifts it from the ground to the quiver. (Assume $g = 10\text{ m/s}^2$)

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Ans :

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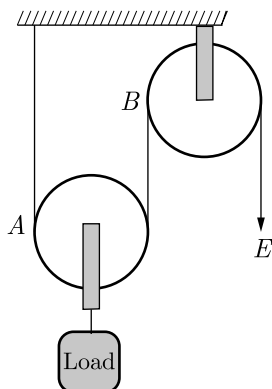
- (i) The weight of the metre scale acts at its centre of gravity i.e., at 50 cm mark by the concept of moments, we have

$$40 \times (30 - 5) = W \times (50 - 30)$$

or $W = (40 \times 25) / 20 = 50 \text{ gf}$

- (ii) F is shifted towards 0 cm.

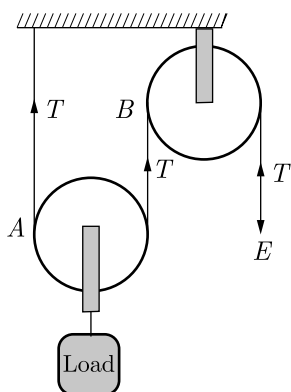
112. The diagram below shows a pulley arrangement :



- (i) Copy the diagram and mark the direction of tension on each strand of the string.
 (ii) What is the velocity ratio of the arrangement?
 (iii) If the tension acting on the string is T , then what is the relationship between T and effort E ?
 (iv) If the free end of the string moves through a distance x , find the distance by which the load is raised.

Ans :

- (i) The direction of tension is as marked.



- (ii) VR = Distance travelled by effort / Distance travelled by load $= \frac{2x}{x} = 2$
 The distance travelled by load is half the distance moved by effort $= \frac{x}{2}$.

(iii) $T = E$

(iv) The distance travelled by load is half the distance moved by effort $= \frac{x}{2}$.

113. A boy uses a single fixed pulley to lift a load of 50 kgf to some height. Another boy uses a single movable pulley to lift the same load to the same height. Compare the effort applied by them. Give a reason to support your answer.

Ans :

COMP 2017

A single fixed pulley simply changes the direction of the action of the force. Therefore, for this pulley $E = L = T = 50 \text{ kgf}$. Thus, it has a mechanical advantage 1.

For a single movable pulley, we have $L = T + T = 2T$ and $E = T = L/2 = 50/2 = 25 \text{ kgf}$,

Therefore, its mechanical advantage is 2.

114. A pulley system with velocity ratio = 4 is used to lift a load of 175 kgf through a vertical height of 15 m. The effort required is 50 kgf in the downward direction, ($g = 10 \text{ N kg}^{-1}$). Calculate :

- (i) Distance moved by the effort.
 (ii) Work done by the effort.
 (iii) M.A. of the pulley system.
 (iv) Efficiency of the pulley system.

Ans :

Given, V.R. = 4,

$L = 175 \text{ kgf}$, distance moved by load $= d_L = 15 \text{ m}$, $E = 50 \text{ kgf}$, $d_E = ?$, $W_E = ?$, M.A. = ?, $h = ?$

Using the formula,

$$\begin{aligned} \text{V.R.} &= \frac{\text{distance moved by effort}}{\text{distance moved by load}} \\ &= \frac{d_E}{d_L} \end{aligned}$$

Therefore, we have

$$\begin{aligned} d_E &= \text{V.R.} \times d_L \\ &= 4 \times 15 = 60 \text{ m} \end{aligned}$$

$$\begin{aligned} W_E &= \text{Effort} \times d_E \\ &= 50 \times 10 \times 60 = 30000 \text{ J} \end{aligned}$$

Now, $\text{M.A.} = \frac{\text{Load}}{\text{Effort}} = \frac{175}{50} = 3.5$

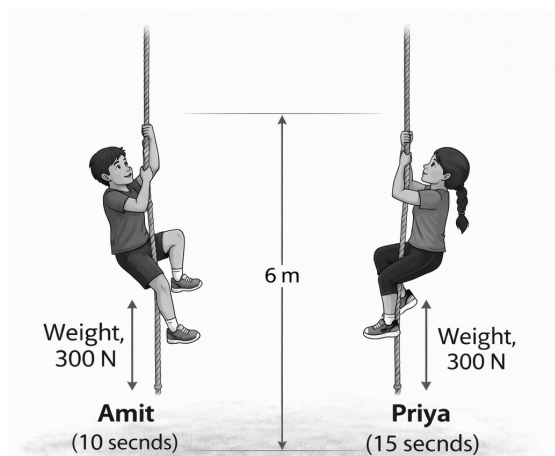
$$\begin{aligned} \eta &= \frac{\text{M.A.}}{\text{V.R.}} = \frac{3.5}{4} \\ &= 0.875 = 87.5\% \end{aligned}$$

115. A block and tackle system has V.R. = 5.

- (a) Draw a neat labelled diagram of a system indicating the direction of its load and effort.

- (c) As the coaster cars drop, their height above the ground decreases, causing a loss in potential energy. This lost potential energy is continuously converted into kinetic energy, resulting in a drastic increase in the cars' speed.
- (d) The total mechanical energy of the coaster remains constant throughout the drop. This is supported by the law of conservation of mechanical energy, which states that if no external forces like friction act on an object, the sum of its kinetic and potential energy stays constant.

- 185.** Two children, Amit and Priya, both weight 300 N. They both climb a vertical rope to a height of 6 meters. Amit takes 10 seconds to climb, while Priya takes 15 seconds.



- Calculate the work done by Amit in climbing the rope.
- Calculate the work done by Priya in climbing the rope.
- Who has expended more power, Amit or Priya? Calculate the power expended by each.
- What is the SI unit of power?

Ans :

- Work done by Amit

$$= \text{Force (weight)} \times \text{height}$$

$$= 300\text{N} \times 6\text{m} = 1800\text{J}.$$
- Work done by Priya

$$= \text{Force (weight)} \times \text{height}$$

$$= 300\text{N} \times 6\text{m} = 1800\text{J}.$$

(The work done is the same as they have the same weight and climb the same height).

3. Amit has expended more power.

Power of Amit (P_A)

$$= \text{Work done/time taken}$$

$$= 1800\text{J}/10\text{s} = 180\text{W}.$$

Power of Priya (P_P)

$$= \text{Work done/time taken}$$

$$= 1800\text{J}/15\text{s} = 120\text{Watts (W)}.$$

4. The SI unit of power is the Watt (W), which is equivalent to Joules per second (J/s).

- 186.** A leading car manufacturer is testing the safety brakes of a newly designed vehicle on an isolated, straight test track. The prototype car, which has a mass of 1000 kg, is cruising at a steady speed of 20 m/s. Suddenly, the test driver notices a stop sign and aggressively slams on the brakes. The braking system applies a massive, constant frictional force against the tires, bringing the car to a complete and safe halt over a distance of 40 metres. The engineers monitor the telemetry data to understand the exact work done by the braking system on the vehicle.

QUESTIONS:

- State the work-energy theorem.
- Calculate the initial kinetic energy of the car before the driver applies the brakes.
- Using the work-energy theorem, calculate the total work done by the brakes to stop the car. What does the negative sign in your calculated value indicate?
- Determine the magnitude of the opposing frictional force applied by the braking system over the 40-metre distance.

Ans :

- The work-energy theorem states that the work done on an object by a net force is equal to the change in its kinetic energy.
- Initial kinetic energy

$$= \frac{1}{2} \times \text{mass} \times \text{velocity}^2$$

$$= \frac{1}{2} \times 1000 \text{ kg} \times (20 \text{ m/s})^2$$

$$= \frac{1}{2} \times 1000 \times 400$$

$$= 200,000 \text{ J}.$$
- Change in kinetic energy

$$= \text{Final KE} - \text{Initial KE}$$

$$= 0 \text{ J} - 200,000 \text{ J}$$

$$= -200,000 \text{ J}$$

$$E = 15000 \text{ W h} \times 3600 \text{ s/h}$$

$$= 54,000,000 \text{ J or } 5.4 \times 10^7 \text{ J.}$$

Alternatively, in kilowatt-hours (kWh), which is a commercial unit of energy:

$$E = 1.5 \text{ kW} \times 10 \text{ h}$$

$$= 15 \text{ kWh.}$$

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J, so}$$

$$15 \text{ kWh} = 15 \times 3.6 \times 10^6 \text{ J}$$

$$= 54 \times 10^6 \text{ J}$$

$$= 5.4 \times 10^7 \text{ J}$$

- 167.** An object of mass 40 kg is raised to a height of 5 m above the ground.
- What is its potential energy at this height? (Take $g = 10 \text{ m/s}^2$)
 - If the object is allowed to fall, find its kinetic energy when it is half-way down.
 - What is its kinetic energy just before it hits the ground? (Assume conservation of mechanical energy).

Ans :

Given: Mass $m = 40 \text{ kg}$, Height $h_{\text{initial}} = 5 \text{ m}$, and $g = 10 \text{ m/s}^2$.

- (a) Potential Energy at height 5 m:

$$E_p = mgh_{\text{initial}}$$

$$= 40 \text{ kg} \times 10 \text{ m/s}^2 \times 5 \text{ m}$$

$$= 2000 \text{ J.}$$

The total mechanical energy at the start (all potential) is 2000 J.

- (b) Kinetic Energy when half-way down:
Half-way down means the object has fallen a distance of $\frac{5\text{m}}{2} = 2.5 \text{ m}$.

Its height above ground is now $h_{\text{half}} = 2.5 \text{ m}$.

Potential energy at half-way point,

$$E_{p \text{ half}} = mgh_{\text{half}}$$

$$= 40 \times 10 \times 2.5$$

$$= 1000 \text{ J.}$$

By conservation of mechanical energy,

$$\text{Total Energy} = E_{p \text{ half}} + E_{k \text{ half}}.$$

$$2000 \text{ J} = 1000 \text{ J} + E_{k \text{ half}}.$$

Kinetic energy when half-way down,

$$E_{k \text{ half}} = 2000 \text{ J} - 1000 \text{ J}$$

$$= 1000 \text{ J.}$$

- (c) Kinetic Energy just before it hits the ground:
Just before hitting the ground, its height is approximately 0 m, so its potential energy

$$E_{p \text{ ground}} \approx 0 \text{ J.}$$

By conservation of mechanical energy,

$$\text{Total Energy} = E_{p \text{ ground}} + E_{k \text{ ground}}.$$

$$2000 \text{ J} = 0 \text{ J} + E_{k \text{ ground}}.$$

Kinetic energy just before hitting the ground,

$$E_{k \text{ ground}} = 2000 \text{ J.}$$

This means all its initial potential energy has been converted into kinetic energy.

- 168.** A certain household has consumed 250 units of energy during a month. How much energy is this in joules? If this energy was consumed by an appliance with an average power of 500 W, for how many hours was the appliance used?

Ans :

The “unit” of energy consumed in households is the kilowatt-hour (kWh).

1 unit = 1 kWh.

So, energy consumed = 250 units = 250 kWh.

To convert kWh to joules:

$$1 \text{ kWh} = 1 \text{ kilowatt} \times 1 \text{ hour}$$

$$= 1000 \text{ watts} \times 3600 \text{ seconds}$$

$$= 1000 \text{ J/s} \times 3600 \text{ s}$$

$$= 3,600,000 \text{ J}$$

$$= 3.6 \times 10^6 \text{ J.}$$

Energy consumed in joules

$$= 250 \text{ kWh} \times 3.6 \times 10^6 \text{ J/kWh}$$

$$= 900 \times 10^6 \text{ J} = 9 \times 10^8 \text{ J.}$$

The energy consumed is 9×10^8 joules.

Now, if this energy was consumed by an appliance with average power $P = 500 \text{ W}$.

Energy $E = 9 \times 10^8 \text{ J}$.

We know Power

$$P = \frac{\text{Energy}(E)}{\text{Time}(t)},$$

$$\text{So, Time } t = \frac{\text{Energy}(E)}{\text{Power}(P)}$$

$$= \frac{9 \times 10^8 \text{ J}}{500 \text{ W}}$$

$$= \frac{9 \times 10^8 \text{ J}}{500 \text{ J/s}}$$

$$= \frac{900000000}{500} \text{ s}$$

$$= 1,800,000 \text{ seconds.}$$

(d) Work done = mgh
 $= 2000 \text{ kg} \times 10 \text{ m/s}^2 \times 10 \text{ m}$
 $= 200,000 \text{ J}.$

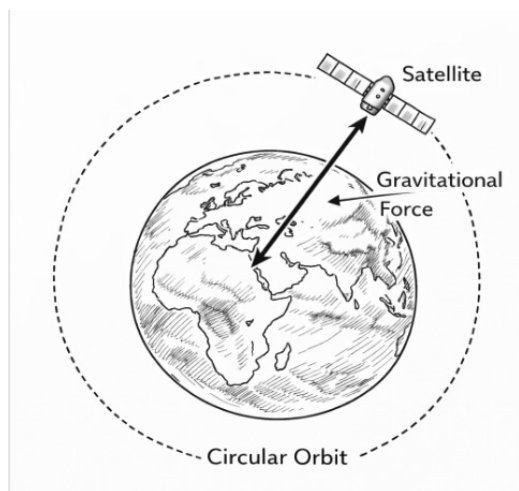
(e) Power of Ram's pump
 $= \text{Work/time}$
 $= 200,000 \text{ J}/100 \text{ s}$
 $= 2,000 \text{ W}.$

Power of Shyam's pump
 $= \text{Work/time}$
 $= 200,000 \text{ J}/40 \text{ s}$
 $= 5,000 \text{ W}.$

Shyam's pump develops higher power because it completes the same work in significantly less time.

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- 189.** A satellite is revolving around the Earth in a circular orbit at a constant speed. The Earth's gravitational force is constantly acting on the satellite, directed towards the center of the Earth.



1. What is the direction of the Earth's gravitational force acting on the satellite?
2. What is the direction of the satellite's displacement at any instant during its circular motion? .
3. What is the angle between the gravitational force and the instantaneous displacement of the satellite?
4. How much work is done by the Earth's gravitational force on the satellite as it orbits the Earth? Explain.

Ans :

1. The Earth's gravitational force acts towards the center of the Earth (it's the centripetal force).
2. The satellite's instantaneous displacement (or velocity direction) is tangential to the circular orbit at any point.
3. The angle between the gravitational force (directed radially inwards) and the instantaneous displacement (directed tangentially) is 90° .
4. The work done by the Earth's gravitational force on the satellite is zero. This is because the force of gravity is always perpendicular to the direction of the satellite's instantaneous displacement. Work done $W = F \cos \theta$, and if $\theta = 90^\circ$, then $\cos 90^\circ = 0$, so $W = 0$.

- 190.** On Independence Day, the school principal proudly hoists the national flag in the main courtyard. A long, sturdy rope is attached to the flag, passing through a small, grooved wheel securely fixed at the very top of a tall metal flagpole. When the principal pulls the rope downwards, the flag moves upwards smoothly. Later that afternoon, construction workers at the school are seen using a similar grooved wheel system. However, their wheel is attached directly to a heavy load of bricks and moves vertically up and down along with the load, helping them lift materials with minimal effort.

QUESTIONS:

- (a) What is the specific name of the simple machine fixed at the top of the school's flagpole?
- (b) Does the fixed wheel at the top of the flagpole reduce the magnitude of force the principal needs to apply? Why is it used?
- (c) How does the simple machine used by the construction workers differ from the one used for the flagpole in terms of mechanical advantage?

Ans :

- (a) The simple machine at the top of the flagpole is called a fixed pulley.
- (b) No, a fixed pulley does not reduce the required force; its mechanical advantage is 1. It is used because it provides convenience by changing the direction of the effort, allowing the principal to pull downwards to lift the flag upwards.

7.2 Conclusions Drawn by Rutherford

1. As most α -particles passed through the gold foil without any deflection from their path, most of the space inside the atom is vacant.
2. α -particles, being heavy and carrying two units of positive charge, could only be deflected some heavy and positively charged body inside the atom.
3. As very few α -particles are deflected back, this heavy and positively charged body inside the atom is very small in volume. This heavy, rigid and positively charged body located within the atom was called nucleus.

8. DISCOVERY OF NEUTRON

In 1932, James Chadwick discovered that when beryllium or boron is bombarded by α -particles, a highly penetrating radiation is emitted. It contains new particles carrying no electrical charge (i.e., neutral) and having mass nearly equal to that of proton. These new particles were called neutrons. The neutron is slightly heavier than proton with a mass of 1.6749×10^{-27} kg.

Protons and neutrons are present in the nucleus of the atom. These two particles, along with electron are sometimes, called elementary particles. Their relative properties are given in the following table.

	Property	Electron	Proton	Neutron
1.	Symbol	e or e^-	p or p^+	n
2.	Discovered by	JJ Thomson	Goldstein	James Chadwick
3.	Electrical nature	Negatively charged	Positively charged	Neutral (no charge)
4.	Absolute charge	-1.6×10^{-19} C	$+1.6 \times 10^{-19}$ C	Zero
5.	Relative charge	-1	+1	0
6.	Absolute mass	9.11×10^{-28} g	1.67×10^{-24} g	1.675×10^{-24} g
7.	Relative mass	1/1840	1	1

9. BOHR'S MODEL OF ATOM

In 1913, a Danish physicist and Nobel laureate, Neils Bohr developed a new model of atom to overcome the drawbacks of Rutherford's model of atom. This is called Bohr's model of atom.

Bohr's model of atom states that :

1. Electrons revolve around the nucleus in circular orbits.
2. Out of the several possible circular orbits, the electron is allowed to revolve only in certain permissible orbits.
3. The allowed orbits are associated with a definite fixed amount of energy. Therefore, these orbits are called stationary states or energy levels or shells.

The energy levels or shells are designated by letters K, L, M, N, O, ..., etc. or as 1, 2, 3, 4, 5, ..., etc. The K-orbit or the first orbit is nearest to the nucleus and has the lowest energy.

The order of energies of these shells is as follows: $K < L < M < N < O \dots$

or $1 < 2 < 3 < 4 < 5 \dots$

4. As long as electron revolves in the allowed energy level or shell, it does not radiate energy, i.e., the energy of an electron remains constant in a particular orbit.
5. When an electron jumps from lower energy level or lower orbit to higher energy level or higher orbit, it absorbs energy but when it jumps from higher energy level or orbit to lower energy level or orbit, it emits energy.

10. ATOMIC NUMBER

The number of unit positive charge carried by the nucleus of an atom is termed as the atomic number (Z) of the atom. As a proton carries one unit positive charge, hence, atomic number of an element is equal to the number of protons present in the nucleus of its atom.

1. Since the atom is electrically neutral, the number of protons and electrons is also equal in an atom. So, atomic number (Z) is equal to the number of electrons in the atom.
2. Based on his studies, Moseley concluded that atomic number (Z) is a fundamental property of the atom. No two elements have the same atomic number.

side. To successfully balance the seesaw horizontally in the air, Meera slides her seating position further back towards the edge of the board.

QUESTIONS:

- Identify the fulcrum in the context of the seesaw.
- Which specific class of lever does a seesaw represent, and why?
- State the principle of a lever mathematically, relating effort, load, and their respective arms.
- At what exact distance from the pivot must Meera sit to perfectly balance the seesaw horizontally?
- Explain the scientific principle behind how Meera, despite having a smaller mass, is able to balance Aryan's heavier mass on the seesaw.

Ans :

- The fixed central pivot point on which the wooden board rests is the fulcrum.
- A seesaw represents a Class I lever because the fulcrum is situated between the load (Aryan's weight) and the effort (Meera's weight).
- The principle of a lever mathematically is: effort $\times$ effort arm = load $\times$ load arm.
- Using the principle of levers: $30 \text{ kg} \times \text{Distance (L)} = 40 \text{ kg} \times 1.5 \text{ m}$. Therefore, $30 \times L = 60$, which gives $L = 2$ metres. Meera must sit 2 metres from the pivot.
- A lever allows a smaller force to overcome a larger force by increasing the distance of the smaller force from the fulcrum. Meera balances Aryan by sitting further away from the pivot, increasing her effort arm, which compensates for her smaller mass and equalizes the turning effect on both sides.

- 194.** A car of mass 1000 kg is moving with a uniform velocity of 20 m/s. The driver then applies brakes and the car comes to rest after travelling some distance.

- Calculate the initial kinetic energy of the car when it was moving at 20 m/s.
- What is the kinetic energy of the car when it comes to rest?
- What is the work done by the braking force to stop the car?
- If the car had doubled its speed to 40 m/s, how would its initial kinetic energy change?

Ans :

- Initial kinetic energy

$$\begin{aligned}(E_k) &= \frac{1}{2}mv^2 \\ &= \frac{1}{2} \times 1000\text{kg} \times (20\text{m/s})^2 \\ &= \frac{1}{2} \times 1000 \times 400 = 200,000\text{J}\end{aligned}$$

- When the car comes to rest, its velocity is 0 m/s, so its kinetic energy is

$$= \frac{1}{2} \times 1000\text{kg} \times (0\text{m/s})^2 = 0\text{J}.$$

- The work done by the braking force is equal to the change in kinetic energy of the car.

Work done = Final E_k - Initial

$$\begin{aligned}E_k &= 0\text{J} - 200, \\ 000\text{J} &= -200,000\text{J}\end{aligned}$$

The negative sign indicates that the work is done by the force opposing the motion.

- If the speed doubled to 40 m/s, the kinetic energy would be

$$\begin{aligned}E_k &= \frac{1}{2} \times 1000\text{kg} \times (40\text{m/s})^2 \\ &= \frac{1}{2} \times 1000 \times 1600 = 800,000\text{J}.\end{aligned}$$

This is four times the initial kinetic energy (since $E_k \propto v^2$).

- 195.** A coconut of mass 2 kg is attached to a tree at a height of 10 meters above the ground. It then detaches and falls freely to the ground. (Assume $g = 9.8\text{m/s}^2$ and neglect air resistance).

- What is the potential energy of the coconut when it is at a height of 10 meters?
- What is the kinetic energy of the coconut just before it hits the ground (assuming all potential energy is converted to kinetic energy)?
- According to the law of conservation of energy, what is the sum of potential and kinetic energy of the coconut at any point during its fall?
- At what point during its fall is the coconut's kinetic energy at a maximum? At what point is its potential energy at a maximum?

Ans :

- Potential energy

$$\begin{aligned}(E_p) &= mgh \\ &= 2\text{kg} \times 9.8\text{m/s}^2 \times 10\text{m} = 196\text{J}.\end{aligned}$$

CHAPTER 8

Journey Inside the Atom

SUMMARY

1. REDISCOVERING THE ROOTS OF ATOMIC THEORY

1. Acharya Kanada in ancient India suggested that dividing matter repeatedly leads to the smallest indivisible particles called parmanus.
2. His ideas are recorded in the Sanskrit text Vaisesika Sutras.
3. Combinations of parmanus form dyads and triads to create the entire material universe.
4. Greek philosophers Leucippus and Democritus also proposed similar indivisible particles called atomos.
5. The word atomos means indivisible in Greek.
6. John Dalton proposed his atomic theory in 1808 based on scientific experiments of his time.
7. Dalton stated that all matter is composed of indivisible building blocks called atoms that cannot be broken down further.
8. Dalton's theory was the first scientific description of how matter is made.

2. A SHORT HISTORICAL JOURNEY THROUGH ATOMIC MODELS

1. Scientists believed atoms were the smallest indivisible units of matter until the late 19th century.
2. The discovery of radioactivity showed that atoms emit invisible energy and particles.
3. This phenomenon proved that atoms are composed of smaller subatomic particles.
4. J J Thomson studied the conduction of electric current through low pressure gases in 1897.

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5. He used a glass vacuum tube with a negative cathode and a positive anode connected to a high voltage supply.
6. He observed rays moving from the cathode to the anode and called them cathode rays.
7. Cathode rays are streams of tiny negatively charged particles called electrons.
8. Electrons have a much smaller mass than atoms and are fundamental components of all elements.
9. The charge of an electron is taken as minus 1 for convention and convenience.
10. J J Thomson received the Nobel Prize in Physics in 1906 for his discovery of the electron.

3. ELECTRICAL NATURE OF MATTER

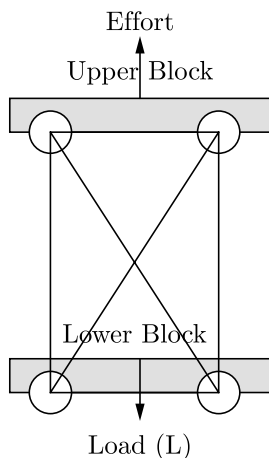
Since very early times, electrical nature of matter is known from the experiments on the production of frictional electricity, e.g., when a comb is rubbed with dry hair and then brought near small pieces of paper, it attracts pieces of paper. As matter is composed of atoms, there is an indication of the presence of charge in an atom.

4. DISCOVERY OF ELECTRON

In 1879, William Crookes studied the conduction of electric current through gases at low pressure. When he applied a high electric discharge of about 10,000 volts between the electrodes, following observations were made:

1. When the pressure of the gas inside the discharge tube was 1 atm, electric current did not flow between electrodes because gases as such are bad conductors of electricity.
2. When the pressure of the gas was reduced to 10^{-2} atm, electric current started to flow between electrodes and a coloured glow was formed.

- 198.** Let's consider a block and tackle pulley system with 4 pulleys (2 in the upper block and 2 in the lower block) to illustrate the concepts.



- What is the mechanical advantage (MA) of the given block and tackle system if the weight of the pulleys is negligible?
- If the load (L) to be lifted is 200 N, what is the effort (E) required to lift the load using this block and tackle system?
- What is the velocity ratio (VR) of the given block and tackle system?
- If the efficiency (η) of the block and tackle system is 80%, what is the actual effort required to lift the 200 N load?

Ans :

- The mechanical advantage (MA) of the system is equal to the number of pulleys in the system. In this case, with 4 pulleys, the MA is 4.

$$MA = 4$$

- The effort required (E) can be calculated using the mechanical advantage (MA).

Given that MA = 4,

$$\begin{aligned} E &= \frac{L}{MA} \\ &= \frac{200 \text{ N}}{4} \\ &= 50 \text{ N} \end{aligned}$$

- The velocity ratio (VR) is also equal to the number of pulleys in the system. For this system with 4 pulleys, the VR is 4.

$$VR = 4$$

- The actual effort required considering the efficiency (η) can be calculated as

$$\eta = \frac{MA}{VR}$$

Given, $\eta = 0.8$ (or 80%)

$$\eta = \frac{MA}{VR}$$

$$0.8 = \frac{4}{VR}$$

$$VR = 4$$

The actual effort required (E_{actual}) considering the efficiency

$$\begin{aligned} E_{\text{actual}} &= \frac{E}{\eta} \\ &= \frac{50 \text{ N}}{0.8} = 62.5 \text{ N} \end{aligned}$$

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PAUSE AND PONDER

- Suppose you made up your own 'atom', as Thomson described, using clay for the positive charge and small beads for the electrons spread through it. What will happen if:

- the positive charge on the clay is lesser than the total negative charge of the beads?
- by mistake, the clay itself carries a bit of negative charge? Would your model still represent a neutral atom?

Ans :

- If the positive charge on the clay is less than the total negative charge of the beads, the overall atom would become a negatively charged ion. This contradicts the fundamental observation that atoms in their normal state are electrically neutral.
 - Your model would no longer represent a neutral atom because the clay is supposed to be the sole source of balancing positive charge. If the clay carries a negative charge, the entire structure becomes overwhelmingly negative and cannot balance the negative charge of the beads.
- Could an orange or a lemon, which also contain seeds inside soft pulp, be a good comparison? In what ways does it match Thomson's idea and where does it fall short?

Ans :

An orange or lemon can be a reasonable comparison because the discrete seeds embedded within the soft pulp nicely represent the negatively charged electrons scattered within a larger positive mass. However, it falls short because Thomson's model describes the positive charge as a uniform, continuous sphere, whereas a citrus fruit has broken segments, empty spaces, and a thick outer rind that do not represent a uniform positive field.

- Why did Thomson conclude that electrons are present in all atoms?

Ans :

Thomson found that the nature of the cathode rays, which consist of electrons, was completely independent of the material of the cathode or the gas used inside the vacuum tube. Because every different element he tested emitted the exact same negatively charged, lightweight particles,

he logically concluded that electrons must be a fundamental subatomic component present in all atoms.

- What do you think would happen if alpha-particles were replaced with negatively charged particles in Rutherford's gold foil experiment?

Ans :

If negatively charged particles were used, they would be attracted to the densely packed, positively charged nucleus instead of being repelled by it. As a result, many particles might be deflected inward towards the nucleus or captured entirely, meaning we would not observe the sharp backward scattering that occurs due to electrostatic repulsion.

- Rutherford found that a few alpha-particles bounced back sharply. How does this single surprising result completely rule out Thomson's 'plum pudding model' of the atom?

Ans :

In Thomson's model, the positive charge and mass are spread thinly and evenly throughout the entire atom, meaning an energetic, heavy alpha particle should easily punch straight through with at most a slight deflection. The fact that a few alpha particles bounced backward meant they must have collided with something incredibly dense and highly positively charged. This single observation proved that the positive mass is not spread uniformly, but is instead concentrated into a tiny, massive central nucleus.

- If you could ask Rutherford one question about his work, what would it be?

Ans :

I would ask him what his initial reaction was at the exact moment his assistants reported that some alpha particles had actually bounced backward. I would love to know if he immediately realized the plum pudding model was wrong or if he first suspected an error in the experiment.

- Assertion (A):** Rutherford concluded that most of the mass of an atom is concentrated in a small region at the centre called the nucleus.

Reason (R): According to Thomson's model, electrons are embedded in a uniformly distributed positive charge sphere.

3. When the pressure was further reduced to about 10^{-4} atm, the glow between the electrodes disappeared but current kept on flowing and the tube glowed with a faint greenish light.

When a hole was made in the anode and the tube behind the anode was coated with some fluorescent material like ZnS, a bright spot was seen on the coating which showed that some invisible rays are being emitted from the cathode. These rays are known as cathode rays.

Thus, it was concluded that cathode rays are stream of particles or pieces of atom having a negative charge. J J Thomson named these subatomic particles as corpuscles of negative electricity. Later, corpuscles changed to electron, on the suggestion of G J Stoney, that means particles or atoms of electricity. An electron is shown by the symbol e or e^{-1} .

4.1 Charge of Electron

Charge on electron was determined by R A Millikan. An electron has a negative charge of 1.6022×10^{-19} coulomb or 4.8×10^{-10} esu which is the smallest measurable quantity of charge and is called one unit of electrical charge. So, we say that electron has 1 unit of negative charge.

4.2 Mass of an Electron

The mass of an electron (m_e) is 9.11×10^{-31} kg or 9.11×10^{-28} g. It is negligibly small and is $1/1840$ times the mass of a hydrogen atom.

5. DISCOVERY OF PROTON

When a high electric discharge was passed through the gas at low pressure, it was observed that some rays, coming from the anode, passed through the perforated cathode. They produced green fluorescence on the opposite glass wall coated with zinc sulphide. These rays were called anode (canal) rays as they passed through canals, i.e., holes in the cathode. They were named positive rays as they carry positive charge. The positive charge on these particles is same in magnitude as on electron, i.e., 1.6×10^{-19} C. These subatomic particles were called protons.

5.1 Mass of a Proton

The mass of a proton is extremely small but very important in understanding the structure of an atom. A proton has a mass of approximately (m_p) is 1.67×10^{-24} g or 1.67×10^{-27} kg.

A proton is a positively charged particle found in the nucleus of an atom, along with neutrons. Although its mass is very tiny in everyday terms, it contributes significantly to the total mass of an atom. In fact, most of the mass of an atom is concentrated in its nucleus, which contains protons and neutrons.

6. THOMSON'S MODEL OF ATOM

J J Thomson in 1904 proposed that an atom is a uniform sphere of positive electricity in which electrons are embedded and the number of electrons embedded is such that the total negative charge on all electrons is same as the positive charge. Thus, the atom as a whole is electrically neutral.

This model is called plum-pudding model, in which the pudding shows the sphere of positive electricity and electrons the bits of plums scattered in the pudding. Thus, Thomson's model of atom assumes uniform distribution of mass and charge throughout the volume of the atom.

6.1 Drawbacks of Thomson's Model of Atom

Thomson's model explained the neutrality of atom, but it failed to explain the results of Rutherford's α -ray scattering experiment. Hence, it was rejected ultimately.

7. RUTHERFORD'S X-RAY SCATTERING EXPERIMENT (DISCOVERY OF NUCLEUS)

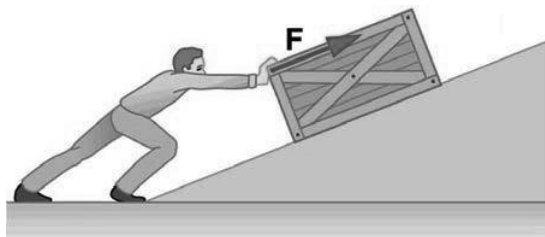
In 1911, British physicist, Ernest Rutherford carried out an experiment in which he directed a narrow beam of α -particles at an extremely thin (about 0.00006 cm thick) gold foil in an evacuated chamber. The presence of α -particles around the thin foil was detected using a circular fluorescent zinc sulphide (ZnS) screen. The point at which an α -particle strikes the screen, a flash of green light is produced.

7.1 Observations

Rutherford observed that most of the α -particles passed through the gold foil without suffering any deflection in their path, some were deflected through wider angles and a very few α -particles (one in 20,000) were deflected through very large angles while some even traversed back their original path.

- (c) The construction workers are using a movable pulley system. Unlike a fixed pulley which has a mechanical advantage of 1, a movable pulley has a mechanical advantage greater than 1, meaning it allows the workers to lift much heavier loads using a smaller effort force.

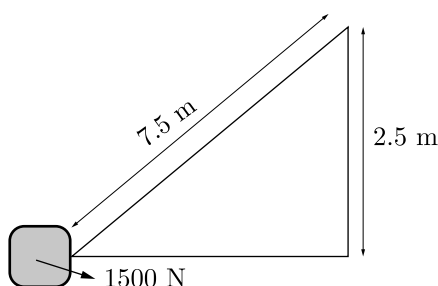
191. A coolie is pushing a box weighing 1500 N up an inclined plane 7.5 m long on to a platform, 2.5 m above the ground.



- (i) Calculate the mechanical advantage of the inclined plane.
 (ii) Calculate the effort applied by the coolie.
 (iii) In actual practice, the coolie needs to apply more effort than what is calculated. Give one reason why you think the coolie needs to apply more effort.

Ans :

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(i)
$$\text{M.A.} = \frac{\text{Length}}{\text{Height}} = \frac{7.5}{2.5} = 3$$

(ii)
$$\text{M.A.} = \frac{L}{E}$$

$$3 = \frac{1500}{E}$$

$$E = 500 \text{ N}$$

- (iii) In actual practice due to friction etc. efficiency is not 100% and velocity ratio is more than mechanical advantage or output is less than work input. So, he needs to apply more effort than calculated.

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192. A logistics company is loading heavy cargo crates, each weighing 1000 N, into a delivery truck. The flat bed of the truck is exactly 1.5 metres above the ground level. The workers initially attempt to lift the crates vertically but find it physically exhausting. They decide to use a sturdy wooden plank as a sliding ramp. First, they try a 3-metre-long ramp, which requires a moderate push. Later, they switch to a longer 5-metre plank. The workers immediately notice a significant difference in how hard they have to push to move the same crates up into the truck.

QUESTIONS:

- (a) What type of simple machine is the wooden ramp used by the workers?
 (b) Calculate the theoretical mechanical advantage of the 3-metre-long ramp.
 (c) How does using the ramp make the work easier for the workers compared to lifting the crates vertically? Mention the physical trade-off involved.
 (d) Explain why the 5-metre-long ramp made it easier to push the crates compared to the 3-metre-long ramp.

Ans :

- (a) The wooden ramp is an inclined plane.
 (b) Mechanical advantage of an inclined plane = Length of the plane (L) / Height (h) = 3 m / 1.5 m = 2.
 (c) The ramp makes work easier by allowing the workers to apply a smaller force over a longer distance to raise the crate to the same height. The trade-off is that while the effort required is smaller, the distance over which the effort must be applied increases, keeping total work done constant.
 (d) The 5-metre ramp is longer, meaning it has a gentler slope. Since mechanical advantage equals Length/Height, increasing the length for the same height increases the mechanical advantage. Therefore, less effort force is required to move the load up the longer ramp.

193. During the recess bell, two children, Aryan and Meera, rush to play on a wooden seesaw in the school playground. The seesaw consists of a long, rigid board resting on a fixed central pivot point. Aryan, who is heavier with a mass of 40 kg, sits 1.5 metres away from the pivot on the left side. Meera, whose mass is 30 kg, sits on the opposite right side. Initially, the seesaw heavily drops down on Aryan's

11. MASS NUMBER

As we know, the entire mass of an atom lies in its nucleus (protons and neutrons). If the mass of proton and neutron is unity, then the total mass of the atom is equal to the sum total of the number of protons and neutrons, called mass number (A) of the atom.

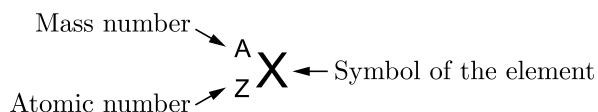
$$\text{Mass number } (A) = \text{Number of protons} + \text{Number of neutrons}$$

$$\text{Mass number } (A) = \text{At. number } (Z) + \text{Number of neutrons}$$

$$[\text{Number of protons} = \text{At. number } (Z)]$$

$$\text{Number of neutrons} = \text{Mass number } (A) - \text{Atomic number } (Z)$$

An atom is symbolised by its chemical symbol with atomic and mass numbers written as subscript and superscript respectively on the left side of the symbol.



12. BOHR-BURY SCHEME OF ELECTRON DISTRIBUTION

In 1921, Bohr and Bury gave identical schemes for the distribution of electrons in different orbits (shells) as follows :

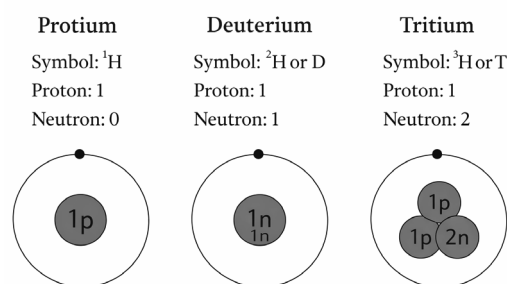
1. The maximum number of electrons accommodated in an orbit (shell) is equal to $2n^2$, where n is the number of shell.
2. The outermost orbit (shell) can have a maximum 8 electrons (octet rule) and the next inner to the outermost (i.e., penultimate shell) can have 18 electrons (if permissible by $2n^2$ rule).
3. It is not essential to fill a shell completely before starting the filling of the next higher shell. When there are 8 electrons in a shell, the next higher shell starts to fill.
4. The outermost shell cannot hold more than 2 electrons and the penultimate shell cannot hold more than 8 electrons unless the preceding inner shell (antepenultimate or the last but two shells) is completely filled according to $2n^2$ rule. Thus, the shells are filled in step wise manner.

13. VALENCE ELECTRONS

The number of electrons present in the outermost shell (valence shell) is called valence electrons. Chemical properties of elements depend on the number of valence electrons.

14. ISOTOPES

Atoms of the same element having same atomic number but different mass numbers are called isotopes. As isotopes have same atomic number, i.e., the same number of protons, the difference in mass number is due to the presence of different number of neutrons in the nucleus, e.g., hydrogen has three isotopes with mass numbers 1, 2 and 3 but they all have same atomic number, i.e.,



15. FRACTIONAL ATOMIC MASSES OF SOME ELEMENTS

Many elements occur as a mixture of their isotopes. As atomic mass of an element is the average relative mass of all the naturally occurring isotopes of that element, the atomic mass of some elements is a fractional value which depends upon the masses of isotopes and their natural abundance in the element.

15.1 Radioisotopes

Some elements have one or more unstable isotopes. These unstable isotopes decay emitting α -particles or β -particles along with gamma (γ) rays. Such isotopes are called radioisotopes. For example, C-14 is a radioactive isotope of carbon.

16. ISOBARS

Atoms of different elements having same mass number but different atomic numbers are called isobars. For example, ${}^{40}_{18}\text{Ar}$, ${}^{40}_{19}\text{K}$ and ${}^{40}_{20}\text{Ca}$ are some isobars.

2. Just before it hits the ground ($h=0$), all its initial potential energy is converted into kinetic energy. So, its kinetic energy will be 196 J.
3. According to the law of conservation of energy, the sum of potential and kinetic energy (total mechanical energy) of the coconut remains constant at any point during its fall, which is 196 J.
4. The coconut's kinetic energy is at a maximum just before it hits the ground (when its velocity is highest). Its potential energy is at a maximum when it is at its initial height of 10 meters (before it starts falling).

196. An electric bulb is rated as 100 W. It is used for 5 hours daily.

1. What does "100 W" rating for the bulb signify?
2. How much electrical energy does the bulb consume in 1 second?
3. Calculate the total electrical energy consumed by the bulb in joules if it is used for 5 hours.
4. The "unit" of energy often mentioned in electricity bills is kilowatt-hour (kWh). How many joules are there in 1 kWh?

Ans :

1. "100 W" rating signifies that the bulb consumes electrical energy at the rate of 100 joules per second.
2. The bulb consumes 100 joules of electrical energy in 1 second.
3. Time = 5 hours = $5 \times 60 \times 60 = 18000$ s
Energy consumed

$$\begin{aligned}
 &= \text{Power} \times \text{Time} \\
 &= 100\text{W} \times 18000\text{s} \\
 &= 1,800,000\text{J or } 1.8 \times 10^6\text{J.}
 \end{aligned}$$

4. 1 kWh = 1 kilowatt $\times$ 1 hour

$$\begin{aligned}
 &= 1000\text{W} \times 3600\text{s} \\
 &= 1000\text{J/s} \times 3600\text{s} \\
 &= 3,600,000\text{J or } 3.6 \times 10^6\text{J.}
 \end{aligned}$$

197. A construction site worker needs to lift a heavy concrete block weighing 300 kg using a lever. The worker can apply a maximum effort of 100 kg. To achieve this, the worker uses a Class I lever where the distance from the fulcrum to the point where the effort is applied (effort arm) is 3 meters, and the distance from the fulcrum to the load (load

arm) is 1 meter.

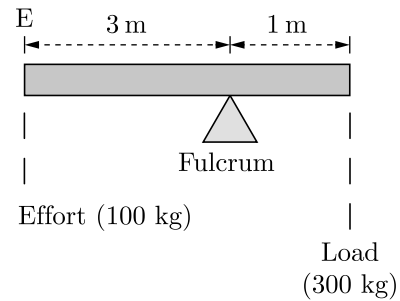


Illustration of a Class I lever where effort (E), load (L), and fulcrum (F) are shown.

- (i) Calculate the mechanical advantage (MA) of the lever.
- (ii) Determine if the worker can lift the concrete block with the given lever setup.
- (iii) Calculate the velocity ratio (VR) of the lever.
- (iv) What is the efficiency (η) of the lever if it is an ideal machine?

Ans :

- (i) The mechanical advantage (MA) of the lever is calculated using the formula:

$$\begin{aligned}
 \text{MA} &= \frac{\text{Load}}{\text{Effort}} \\
 &= \frac{300\text{ kg}}{100\text{ kg}} = 3
 \end{aligned}$$

- (ii) Effective Force = Effort $\times$ MA

$$\begin{aligned}
 &= 100\text{ kg} \times 3 \\
 &= 300\text{ kg}
 \end{aligned}$$

Thus, the worker can lift the 300 kg concrete block with the lever.

- (iii)
$$\begin{aligned}
 \text{VR} &= \frac{\text{Effort arm}}{\text{Load arm}} \\
 &= \frac{3\text{ m}}{1\text{ m}} = 3
 \end{aligned}$$

- (iv) For an ideal machine, the efficiency (η) is 100%. In practical terms, efficiency is given by:

$$\eta = \frac{\text{MA}}{\text{VR}} \times 100\%$$

For this ideal lever system:

$$\begin{aligned}
 \eta &= \frac{3}{3} \times 100 \\
 &= 100\%
 \end{aligned}$$

Therefore, the lever operates at 100% efficiency as an ideal machine.

Choose the correct option:

- (i) Both A and R are true, and R is the correct explanation of A.
- (ii) Both A and R are true, but R is not the correct explanation of A.
- (iii) A is true, but R is false.
- (iv) A is false, but R is true.

Ans :

The correct option is (ii) Both A and R are true, but R is not the correct explanation of A.

Assertion A is true Rutherford's gold foil experiment proved mass is concentrated in the nucleus. Reason R is also true Thomson proposed electrons embedded in uniform positive charge. However, R doesn't explain A; Rutherford's conclusion actually disproved Thomson's model.

8. Imagine you are a scientist who has discovered a new element. Name this element after yourself and justify that the symbol you have chosen follows the IUPAC rules.

Ans :

If I discovered a new element and named it "Nivium" after myself, I would assign it the symbol "Nv". This choice perfectly follows IUPAC rules because the first letter "N" is capitalized and the second letter "v" is lowercase. Additionally, it uses the first letter along with another prominent letter from the name, ensuring it does not conflict with existing symbols like "N" for Nitrogen or "Ni" for Nickel.

9. What problems could arise if every scientist used different symbols for the same element?

Ans :

If every scientist used different symbols, it would create massive confusion and communication breakdowns within the global scientific community. Standardized symbols bypass language barriers, so without them, sharing research, writing chemical formulas, and collaborating on international projects would become incredibly tedious and prone to dangerous errors.

10. An atom with an atomic number of 26 has 56 nucleons. Find out its number of electrons, protons and neutrons.

Ans :

The atomic number is 26, so the atom has 26 protons, and since it is a neutral atom, it also has 26 electrons. The number of neutrons is found

by subtracting the atomic number from the total number of nucleons (mass number), which is 56 minus 26, resulting in 30 neutrons.

11. The nucleus of an atom contains 20 protons. If its mass number is 41, find the number of neutrons in it.

Ans :

The number of neutrons is calculated by subtracting the number of protons from the mass number. Therefore, 41 minus 20 gives 21 neutrons.

An atom has 18 neutrons and an atomic number of 17. What is its mass number?

Ans :

The mass number is the sum of the protons (which is equal to the atomic number) and the neutrons. Adding 17 protons and 18 neutrons gives a mass number of 35.

13. An atom ^{23}A has 11 electrons. Find the number of neutrons in it.

Ans :

The notation indicates that the mass number is 23 and the atomic number is 11, meaning it has 11 protons. To find the neutrons, subtract the atomic number from the mass number, which is 23 minus 11, giving 12 neutrons.

14. Identify the number of electrons in the outermost shell of the following elements:

- (i) ${}^6\text{C}^{12}$
- (ii) ${}^9\text{F}^{19}$
- (iii) ${}^{14}\text{Si}^{28}$

Ans :

- (i) Carbon (atomic number 6) has an electronic configuration of 2, 4, so it has 4 electrons in its outermost shell.
- (ii) Fluorine (atomic number 9) has an electronic configuration of 2, 7, so it has 7 electrons in its outermost shell.
- (iii) Silicon (atomic number 14) has an electronic configuration of 2, 8, 4, so it has 4 electrons in its outermost shell.

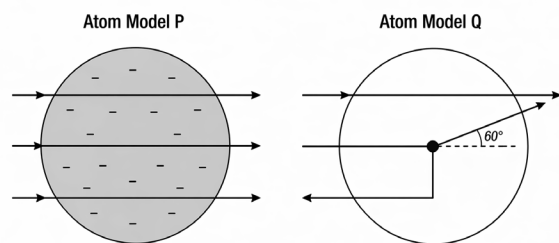
15. Write the electronic configuration of the elements having atomic numbers 12, 16 and 18.

Ans :

For the element with atomic number 12 (Magnesium), the electronic configuration is 2, 8, 2. For the element with atomic number 16 (Sulfur),

Rutherford observed exactly two primary profound phenomena during his famous structural scattering experiment. Most energetic massive alpha particles passed completely effortlessly straight through, mathematically conclusively proving the physical presence of vast internal atomic empty space. A remarkably tiny numerical fraction sharply bounced violently directly backward, proving a dense positively charged core inherently absolutely violently strongly repels identical charges.

7. Based on the trajectories of the incoming positively charged alpha particles shown in the diagram, which of the following statements correctly identifies the atomic models?



- (A) Model P correctly explains the stability of the atom, while Model Q represents Dalton's indivisible atom.
 (B) Model P represents Thomson's uniform positive sphere, while Model Q demonstrates Rutherford's discovery of the dense central nucleus.
 (C) Model P illustrates the planetary model with fixed orbits, while Model Q represents the plum pudding model.
 (D) Model P proves the existence of stationary energy levels, while Model Q proves the existence of neutrons.

Ans : (B)

Model P depicts Thomson's model, predicting that a uniformly distributed positive charge would allow particles to pass with minimal deflection. Model Q represents Rutherford's model, where a incredibly dense, positively charged central nucleus sharply deflects or reflects alpha particles, while the vast empty space allows most to pass straight through.

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8. What is the fundamental relative charge of an electron taken as a matter of standard scientific convention?
 (A) +1
 (B) 0
 (C) -1
 (D) -1.602

Ans : (C)

The fundamental electrical charge of an electron is experimentally determined to be approximately negative one point six zero two multiplied by ten to the power of negative nineteen coulombs. For the sake of mathematical convenience and standard scientific convention across chemical calculations, this specific relative charge is simply taken as exactly negative one.

9. The table displays the specific subatomic composition of four different atomic species. Based entirely on this data, which two species represent isotopes of the exact same chemical element?

Atomic Species	Number of Protons	Number of Neutrons
W	6	6
X	6	8
Y	7	7
Z	8	8

- (A) Species W and Y
 (B) Species X and Y
 (C) Species W and X
 (D) Species Y and Z

Ans : (C)

Isotopes are defined as atoms of the exact same element that share identical atomic numbers but possess different mass numbers. This means they contain the same number of protons but varying numbers of neutrons. Species W and X both contain exactly six protons, making them structurally isotopes of the same chemical element.

10. In Thomson's "plum pudding model," what precisely does the uniform positively charged sphere conceptually represent when compared to a watermelon?
 (A) The dark seeds scattered randomly
 (B) The tough green outer covering
 (C) The red edible soft pulp
 (D) The empty space inside the fruit

Ans : (C)

- (iii) Electrons revolve around the nucleus in orbits of fixed energy without losing energy.
- (iv) Electrons can be found between energy levels as they move around the nucleus.

Ans :

- (i) Incorrect, A key postulate of Bohr's model is that while revolving in discrete, fixed orbits (stationary states), electrons do not radiate or lose energy. This is how Bohr explained the stability of the atom.
- (ii) Incorrect, Bohr's model states that electrons do not move randomly but follow specific fixed circular paths called energy levels or shells (K, L, M, N), each associated with a definite amount of energy.
- (iii) Correct, This is the defining principle of Bohr's stationary states, which resolved the major limitation of Rutherford's model where accelerating electrons were expected to lose energy.
- (iv) Incorrect, According to Bohr's model, electrons can only revolve in allowed shells ($n=1, 2, 3...$) and cannot exist in the spaces between these distinct energy levels.

3. The composition of the nuclei of three atomic species X, Y, and Z are given as follows.

Species	Number of Protons	Number of Neutrons
Species X	18	19
Species Y	17	18
Species Z	17	20

Explain the relation between the following:

- (i) Y and Z
- (ii) Z and X

Ans :

- (i) Species Y and Z are isotopes. They both have the same number of protons (atomic number 17) but different numbers of neutrons (18 and 20, respectively), meaning they are atoms of the same element with different mass numbers.
- (ii) Species Z and X are isobars. The mass number of Z is 37 (17 protons + 20 neutrons) and the mass number of X is also 37 (18 protons + 19 neutrons). They are atoms of different elements (different proton numbers) that have the exact same mass number.

4. What conclusion did Rutherford draw about the position and characteristics of the atom's positively charged part based on the few alpha particles that bounced back or were deflected at large angles in the gold foil experiment?

Ans :

Rutherford concluded that the positively charged part of the atom is not spread uniformly throughout the atom, but is heavily concentrated in an extremely small, dense region at the very center, which he named the nucleus. He deduced this because only a massive, concentrated positive charge could exert enough repulsive force to cause the heavy, fast-moving, positively charged alpha particles to deflect sharply or bounce straight back.

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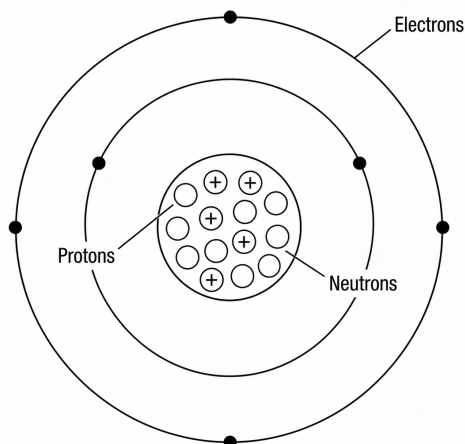
5. Explain and arrange the following statements in the correct chronological order to show how atomic models have evolved over time.
- (i) Bohr's model proposed that electrons move in fixed orbits around the nucleus, each with a definite energy.
 - (ii) Thomson's model depicted the atom as a 'plum pudding' with electrons embedded in a sphere of positive charge.
 - (iii) Rutherford's model proposed that atoms have a dense central nucleus.
 - (iv) Dalton's model described atoms as indivisible particles.

Ans :

The correct chronological order is (iv), (ii), (iii), (i).

First, Dalton proposed his theory that matter is composed of solid, indivisible particles called atoms. Decades later, Thomson discovered the electron and modified this view with his plum pudding model, suggesting the atom was a positively charged sphere containing embedded negative electrons. Later, Rutherford conducted his gold foil experiment, which disproved Thomson's model by revealing that the positive charge is concentrated in a tiny, dense central nucleus. Finally, Bohr refined Rutherford's nuclear model by introducing the concept of stationary orbits to explain why orbiting electrons do not lose energy and collapse into the nucleus.

14. Interpret the atomic structure shown in the diagram. Which of the following options correctly identifies the atomic number, mass number, and valency of this atom respectively?



- (A) Atomic Number: 14, Mass Number: 6, Valency: 4
 (B) Atomic Number: 8, Mass Number: 14, Valency: 6
 (C) Atomic Number: 6, Mass Number: 14, Valency: 4
 (D) Atomic Number: 6, Mass Number: 12, Valency: 2

Ans : (C)

The atomic number equals the total number of protons (6). The mass number is the sum of protons and neutrons ($6 + 8 = 14$). With 6 electrons configured as 2, 4, the outermost valence shell contains 4 electrons. To complete its octet, the atom requires 4 more electrons, resulting in a valency of 4.

15. What specifically is an alpha particle, which Ernest Rutherford uniquely utilized during his famous gold foil scattering experiment?
 (A) A high-energy electron stripped from an orbit
 (B) A neutrally charged particle found strictly inside hydrogen
 (C) A dense nucleus of a helium atom containing two protons and two neutrons
 (D) A high-frequency electromagnetic wave emitted directly from gold

Ans : (C)

During the famous gold foil experiment conducted by Geiger and Marsden strictly under Rutherford's direct guidance, the powerful energetic beam

consisted primarily of alpha particles. An alpha particle is structurally identical to the nucleus of a fundamental helium atom, inherently consisting of exactly two firmly bound protons and exactly two stabilizing internal nuclear neutral neutrons.

16. A researcher records the atomic numbers and mass numbers of three distinct elements in a reference chart. Which of the following statements correctly interprets the scientific relationship between these elements based solely on the provided data?

Element	Atomic Number	Mass Number
P	18	40
Q	19	39
R	20	40

- (A) Elements P and R are isotopes because they have the same mass number.
 (B) Elements P and Q are isobars because they have consecutive atomic numbers.
 (C) Elements P and R are isobars because they share identical mass numbers but distinct atomic numbers.
 (D) Elements Q and R are isotopes because they exhibit different mass numbers and atomic numbers.

Ans : (C)

Isobars are atoms originating from entirely different elements that possess varying atomic numbers but share identical mass numbers. The tabulated data clearly indicates that elements P and R both have a total mass number of exactly forty, despite having completely distinct atomic numbers. This specific relationship classifies them scientifically as true isobars.

17. Arrange the logical analytical steps of Rutherford's gold foil experiment in the correct chronological sequence of scientific progression.
 1. Formulating the planetary model of the atom
 2. Directing a narrow beam of alpha particles at a thin gold foil
 3. Observing the unexpected sharp deflection and bouncing back of specific particles
 4. Concluding that the central positive charge is densely concentrated in a tiny volume
 (A) 2, 3, 4, 1
 (B) 2, 4, 3, 1
 (C) 3, 2, 1, 4
 (D) 4, 2, 3, 1

Ans : (A)

- (c) (i) Aluminium
(ii) Al
(iii) 13
(iv) 3
(v) 3
(vi) 13
(vii) 13
- (d) (i) Fluorine
(ii) F
(iii) 9
(iv) 7
(v) 1
(vi) 9
(vii) 9

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10. Both Rutherford's and Bohr's models have electrons orbiting the nucleus. Why did Rutherford's model fail to explain atomic stability, while Bohr's model succeeded?

Ans :

Rutherford's model failed because it proposed electrons orbiting randomly like planets. According to the laws of physics, a charged particle moving in a circular path accelerates and must continuously radiate energy. Therefore, Rutherford's orbiting electron would lose energy, spiral inward, and collapse into the nucleus. Bohr's model succeeded by introducing the postulate that electrons revolve only in specific, allowed circular paths called stationary states or discrete shells. He established that while moving in these fixed energy levels, electrons do not emit energy, thereby perfectly explaining why the atom remains stable.

11. An atom ^{70}X has 31 electrons. How many neutrons are there in its nucleus?

Ans :

In a neutral atom, the number of protons equals the number of electrons, so this atom has 31 protons. The mass number is given as 70. The number of neutrons is found by subtracting the number of protons from the mass number ($70 - 31$), which means there are 39 neutrons in its nucleus.

12. An atom has 79 protons and a mass number of 197. Calculate (i) the number of neutrons, and (ii) the number of electrons.
(i) the number of neutrons
(ii) the number of electrons

Ans :

- (i) The number of neutrons is 118. This is calculated by subtracting the number of protons from the mass number ($197 - 79 = 118$).
(ii) The number of electrons is 79. Assuming the atom is electrically neutral, it must have the exact same number of negative electrons as it has positive protons.

Complete the Table

Atomic Number	Mass Number	Number of Neutrons	Number of Protons	Number of Electrons	Name of the Element
5	-	6	-	-	-
-	14	-	-	7	Nitrogen
-	24	-	12	-	-
15	-	16	-	-	-
-	1	0	-	-	-

Ans :

Atomic Number	Mass Number	Number of Neutrons	Number of Protons	Number of Electrons	Name of the Element
5	11	6	5	5	Boron
7	14	7	7	7	Nitrogen
12	24	12	12	12	Magnesium
15	31	16	15	15	Phosphorus
1	1	0	1	1	Hydrogen

14. Aman was discussing the structure of atom with his classmates. During the discussion, he learnt that an element X has a mass number of 35 and contains 18 neutrons. Based on this information, answer the following questions:
(i) How many electrons and protons does element X have?
(ii) What is its atomic number?
(iii) Identify the element X.
(iv) Write its electronic configuration.
(v) How many valence electrons does it have?
(vi) What will be the mass number if two neutrons are added to its nucleus?
(vii) What will be the relation of X with the new atom?

6. Electrons move around the nucleus in orbits. Why do they not fly away from the atom? Explain what keeps them attracted to the nucleus.

Ans :

Electrons do not fly away from the atom because they carry a negative electrical charge, while the nucleus contains protons which carry a positive electrical charge. This creates a strong electrostatic force of attraction between the nucleus and the electrons. This attractive force pulls the electrons toward the center, acting as the centripetal force required to keep them moving in their circular orbits around the nucleus.

7. **Assertion (A):** The discovery of subatomic particles helped in understanding the atomic structure.

Reason (R): The number of electrons is equal to the number of protons in an atom.

Choose the correct option:

- Both A and R are true, and R is the correct explanation of A.
- Both A and R are true, but R is not the correct explanation of A.
- A is true, but R is false.
- A is false, but R is true.

Ans :

The correct option is (ii) Both A and R are true, but R is not the correct explanation of A.

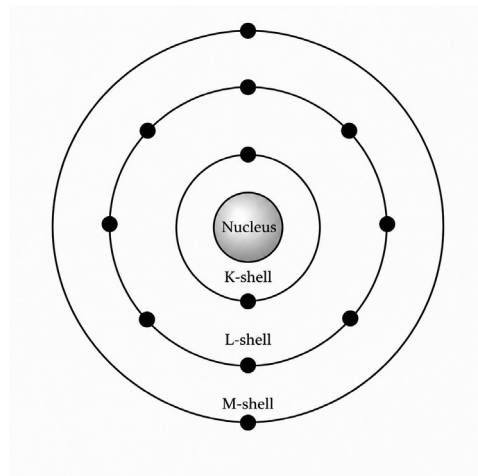
It is true that discovering electrons, protons, and neutrons revealed that atoms have internal structure, proving Dalton's indivisible theory wrong (Assertion A is true). It is also true that in a neutral atom, protons equal electrons (Reason R is true). However, this mathematical equality is not the fundamental reason why the discovery of subatomic particles helped us understand the physical structure and arrangement of the atom.

8. Magnesium is essential for many biological processes, including muscle contraction. For an atom of magnesium with a mass number of 24 and atomic number 12, determine the number of (i) protons, (ii) neutrons, (iii) electrons, and also illustrate the arrangement of electrons in a magnesium atom.

Ans :

- 12 protons (The number of protons is equal to the atomic number).
- 12 neutrons (Calculated by subtracting the atomic number from the mass number: $24 - 12 = 12$).

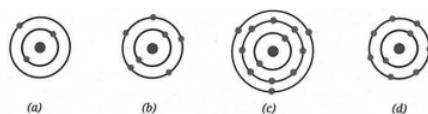
- 12 electrons (In a neutral atom, the number of electrons equals the number of protons).



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9. Find the following information for the elements shown in figure:

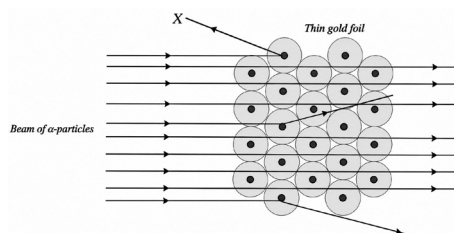
- Name of the element
- Symbol
- Total number of electrons
- Number of valence electrons
- Valency of the element
- Number of protons
- Atomic number



Ans :

- Lithium
 - Li
 - 3
 - 1
 - 1
 - 3
 - 3
- Nitrogen
 - N
 - 7
 - 5
 - 3
 - 7
 - 7

3. In the given setup, the particle marked 'X' undergoes a sharp deflection from its original straight path. What conclusion about the atom's structure can be drawn directly from this specific observation?



- (A) The atom consists mostly of empty space.
 (B) The atom contains a dense, positively charged center.
 (C) Electrons revolve in fixed circular energy levels.
 (D) The positive charge is uniformly distributed throughout.

Ans : (B)

The sharp deflection of the positively charged alpha particle marked 'X' occurs because it experiences a strong repulsive force. This demonstrates that the atom's positive charge and mass are not uniformly distributed but are concentrated in a tiny, dense central region called the nucleus, contradicting the plum pudding model.

vely charged alpha particles inherently violently strongly attracted the densely heavily positively charged central nucleus perfectly.

4. During his experiments with the cathode ray tube, what specific observation led J. J. Thomson to discover the existence of electrons?
- (A) Positively charged particles moving toward the cathode
 (B) Neutral particles moving randomly within the glass tube
 (C) Rays moving from the negatively charged cathode to the positive anode
 (D) Electromagnetic waves emitting bright light independent of electrodes

Ans : (C)

Thomson utilized a cathode ray tube at very low pressure to study electrical conduction inside gases. He observed rays travelling from the negatively charged cathode directly toward the positively charged anode. By applying electric and magnetic fields, he successfully deduced that these rays perfectly consisted of fundamental,

negatively charged particles scientifically called electrons.

5. A student is mapping the distribution of electrons in different energy levels according to the Bohr-Bury scheme. They created a partially filled table. What are the correct numerical values for X and Y required to complete the table?

Shell Name	Shell Number (n)	Maximum Electron Capacity
K	1	2
L	2	8
M	3	X
N	4	Y

- (A) X = 8, Y = 18
 (B) X = 18, Y = 32
 (C) X = 18, Y = 18
 (D) X = 32, Y = 50

Ans : (B)

The maximum number of electrons that can be accommodated in any given shell is determined by the specific mathematical formula $2n^2$, where 'n' represents the orbit number. Applying this rule to the M-shell ($n = 3$), the maximum capacity calculates to $2(3)^2 = 18$. Similarly, for the N-shell ($n = 4$), the capacity reaches $2(4)^2 = 32$.

6. Consider the following observations explicitly derived from Rutherford's alpha-particle scattering experiment.
1. Most alpha particles passed entirely straight through the gold foil without any detectable deflection.
 2. A very remarkably small fraction of alpha particles cleanly completely bounced back at exactly exactly one hundred eighty degrees.
 3. The positively charged alpha particles inherently violently strongly attracted the densely heavily positively charged central nucleus perfectly.

Which of the combinations correctly represents accurate experimental facts from the chapter?

- (A) 1 and 2 only
 (B) 2 and 3 only
 (C) 1 and 3 only
 (D) 1, 2, and 3

Ans : (A)

Ans :

- (i) Element X has 17 protons (Mass number 35 - 18 neutrons = 17) and 17 electrons, as the number of electrons equals the number of protons in a neutral atom.
- (ii) The atomic number is 17, which is equal to the number of protons.
- (iii) Element X is Chlorine (Cl), as chlorine has an atomic number of 17.
- (iv) The electronic configuration of Chlorine (17 electrons) is 2, 8, 7.
- (v) It has 7 valence electrons, which are the electrons present in its outermost shell.
- (vi) The new mass number will be 37 (Original mass 35 + 2 additional neutrons).
- (vii) Element X (mass 35) and the new atom (mass 37) will be isotopes, because they have the same atomic number (17) but different mass numbers due to a different number of neutrons.

15. In an atom, there are 12 protons and 12 neutrons in the nucleus. Now, imagine that all the electrons are replaced with some hypothetical particles that have the same charge as electrons but are 500 times heavier. What effect will this replacement have on the atom's:
- (i) Atomic number
 - (ii) Atomic mass
 - (iii) Mass number
 - (iv) Overall charge

Ans :

- (i) The atomic number will remain unchanged (12). The atomic number is strictly determined by the number of protons in the nucleus, which has not been altered.
- (ii) The atomic mass will increase. Normally, the mass of electrons is negligible compared to the nucleus. Replacing them with particles 500 times heavier adds significant, non-negligible mass to the entire atom.
- (iii) The mass number will remain unchanged (24). Mass number is defined solely as the total number of nucleons (protons + neutrons) inside the nucleus, which remains 12 + 12.
- (iv) The overall charge will remain unchanged (neutral). The hypothetical particles possess the exact same negative electrical charge as normal electrons, so 12 of them will still perfectly balance the positive charge of the 12 protons in the nucleus.

OBJECTIVE QUESTIONS

1. Who among the following ancient Indian philosophers first proposed the concept that dividing matter repeatedly would eventually yield indivisible particles called parmanus?
- (A) Aryabhata
 - (B) Acharya Kanada
 - (C) Maharishi Patanjali
 - (D) Sushruta

Ans : (B)

Acharya Kanada, an ancient Indian philosopher, proposed that continuous division of matter ultimately leads to the smallest indivisible particles, which he named parmanu. This philosophical concept parallels the ideas of ancient Greek thinkers like Democritus, establishing the early theoretical foundation for atomic structure long before experimental scientific theories were developed.

2. A student tabulates the properties of three unknown subatomic particles, labeled P, Q, and R. Based on the characteristics provided in the table, which option correctly identifies these particles?

Particle	Relative Charge	Mass Comparison (Relative to Proton)
P	-1	Negligible
Q	+1	Equal to 1
R	0	Equal to 1

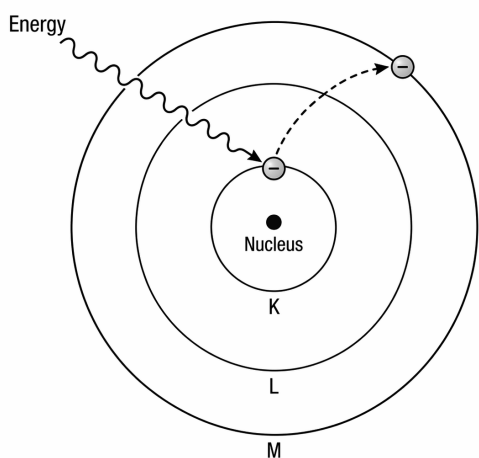
- (A) P: Electron, Q: Proton, R: Neutron
- (B) P: Proton, Q: Neutron, R: Electron
- (C) P: Neutron, Q: Electron, R: Proton
- (D) P: Electron, Q: Neutron, R: Proton

Ans : (A)

Electrons are negatively charged subatomic particles with negligible mass. Protons possess a positive electrical charge and a relative mass of one. Neutrons carry no electrical charge and have a mass nearly identical to that of a proton. The data provided perfectly aligns with these fundamental properties of atomic constituents.

The historically significant Thomson atomic model conceptually utilized remarkably simple visual analogies. He famously and logically compared the atom's uniformly distributed positive background charge directly to the soft, red, sweet edible pulp of a freshly sliced watermelon. Meanwhile, the tiny embedded negatively charged electrons were perfectly compared to the randomly scattered small dark seeds resting inside.

11. What specific atomic process is depicted in the diagram?



- (A) An electron continuously losing energy to stabilize the atomic nucleus.
 (B) An electron absorbing energy to transition to a higher stationary state.
 (C) An electron emitting electromagnetic radiation as it falls to a lower shell.
 (D) A proton transitioning between nuclear energy levels to alter the mass number.

Ans : (B)

Bohr's model states that electrons revolve in discrete energy levels. To transition from a lower energy shell (K) to a higher energy shell (M), an electron must absorb a fixed amount of external energy. Electrons do not lose energy while in a stationary state, and falling inward would emit energy, not absorb it.

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12. The table provides the total number of electrons present in four distinct neutral atoms. Which specific atom is chemically stable and generally unreactive under normal environmental conditions?

Neutral Atom	Total Number of Electrons
A	8
B	10
C	11
D	15

- (A) Atom A
 (B) Atom B
 (C) Atom C
 (D) Atom D

Ans : (B)

The chemical reactivity of an element depends heavily upon the arrangement of its valence electrons. An atom with ten electrons possesses an electronic configuration of two electrons in the first shell and eight in the outermost shell. Having a complete octet renders this specific atom highly stable and chemically unreactive under typical conditions.

13. Identify the correct sequential order of the following historical discoveries related to the structural models of the atom.
- Discovery of fixed energy levels (shells) around the nucleus
 - Postulation that atoms are indivisible foundational building blocks
 - Discovery of the dense positively charged central nucleus
 - Proposal of electrons embedded uniformly within a positive sphere
- (A) 2, 4, 3, 1
 (B) 4, 2, 1, 3
 (C) 2, 3, 4, 1
 (D) 3, 1, 4, 2

Ans : (A)

The evolution of atomic models follows a distinct historical time line based on sequential scientific discoveries. John Dalton first proposed the indivisible atomic theory in eighteen hundred and eight. J.J. Thomson subsequently discovered the electron. Rutherford later discovered the dense central nucleus, which was eventually followed by Bohr's structured energy level model to accurately explain elemental stability.

the configuration is 2, 8, 6. For the element with atomic number 18 (Argon), the configuration is 2, 8, 8.

16. Solve this riddle: I am an atom with a mass number of 23 and 11 protons. I am a soft metal and react vigorously with water. Who am I and how many neutrons do I have? You can also create one such riddle.

Ans :

You are an atom of Sodium (Na) because your atomic number is 11. You have 12 neutrons, which is calculated by subtracting your 11 protons from your mass number of 23.

17. Two different atoms have 11 protons each, but one has 12 neutrons, and the other has 13 neutrons. How do their atomic numbers and mass numbers compare? Are they the same element or different elements?

Ans :

Both atoms have the exact same atomic number of 11 because they possess the same number of protons. However, their mass numbers differ, being 23 (11 protons + 12 neutrons) and 24 (11 protons + 13 neutrons) respectively. Because their atomic numbers are identical, they are isotopes of the exact same element, which is sodium.

18. If a bromine atom is available in the form of, say two isotopes, $^{79}_{35}\text{Br}$ (49.7%) and $^{81}_{35}\text{Br}$ (50.3%), calculate the average atomic mass of the bromine atom.

Ans :

To find the average atomic mass, we take the weighted average of the isotopes:

Assuming the isotopes are ^{79}Br : (49.7%) and ^{81}Br : (50.3%):

$$\begin{aligned}\text{Average mass} &= \frac{(79 \times 49.7) + (81 \times 50.3)}{100} \\ &= \frac{3926.3 + 4074.3}{100} \\ &= \frac{8000.6}{100} \\ &= 80.006 \text{ u} \\ &= 80.0 \text{ u (approximately)}\end{aligned}$$

NCERT EXERCISE

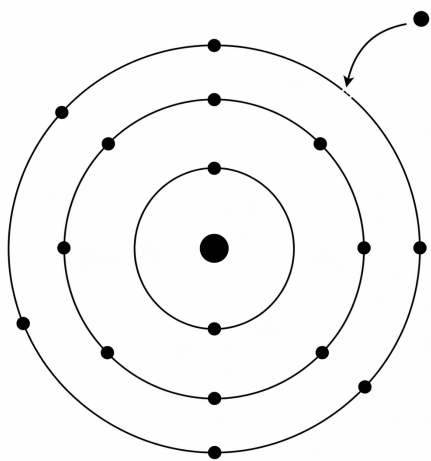
- Choose the correct options and explain the reason for the correct and incorrect options in the context of Ernest Rutherford's gold foil experiment:
 - The experiment clearly showed the existence of neutrons in the nucleus.
 - The results disproved the plum pudding model and led to the idea of a nucleus at the centre of the atom.
 - The large deflection of a few alpha particles indicated that most of the mass of the atom and positive charge are packed into a tiny centre.
 - The way alpha particles were deflected showed that electrons move around the nucleus.

Ans :

- Incorrect, Rutherford's gold foil experiment only indicated the presence of a dense, positively charged center (the nucleus) containing protons. Neutrons were discovered much later by James Chadwick in 1932.
 - Correct, Thomson's plum pudding model assumed positive charge was spread evenly, meaning alpha particles should pass through with minimal deflection. The unexpected large deflections and bounce-backs proved the positive charge was actually concentrated in a tiny central nucleus, disproving Thomson's model.
 - Correct, Because alpha particles are heavy and positively charged, they could only be strongly deflected or bounced back if they hit something much heavier and also positively charged. Since this only happened to a very small fraction of particles, Rutherford concluded this dense, positively charged mass occupies a extremely small region at the center.
 - Incorrect, The deflection of the alpha particles was caused entirely by repulsion from the positively charged nucleus. The experiment provided no direct evidence regarding the paths or behavior of the negatively charged electrons.
- Which of the following statements are correct or incorrect according to the Bohr's atomic model? Give a reason for each statement.
 - Electrons lose energy while moving in fixed orbits and slowly fall into the nucleus.
 - Electrons can exist anywhere around the nucleus with no fixed energy.

Rutherford's analytical process logically predictably logically progressed strictly from fundamental physical experimental setup directly to revolutionary scientific theoretical conclusions. First, he aggressively bombarded a thin gold foil continuously with high-energy external alpha particles. He then observed their unexpected scattering deflection patterns. Based exclusively on these specific internal angular deflections, he eventually logically formulated the planetary structural model.

18. The diagram illustrates a process occurring in a neutral atom to achieve stability. What will be the immediate consequence of this specific process?



- (A) The atom will become a positively charged cation with a valency of 7.
 (B) The atom will become a negatively charged anion with a complete octet.
 (C) The atomic mass of the atom will increase significantly due to the addition.
 (D) The number of protons in the nucleus will increase by one to maintain neutrality.

Ans : (B)

The atom has an initial electronic configuration of 2, 8, 7. It requires one additional electron to complete its outermost shell and achieve a stable octet configuration. By gaining this negatively charged electron, the originally neutral atom acquires a net negative charge, forming an anion. The atomic mass remains virtually unchanged.

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19. The diagram illustrates an atomic model with an electron transitioning between specific pathways. Which statement correctly describes the energy change during this transition?
- (A) The electron continuously loses energy as it revolves in shell R.
 (B) The electron absorbs a specific amount of energy to move from shell P to shell R.
 (C) The electron releases energy because shell R has less energy than shell P.
 (D) The electron's energy remains completely unchanged during the transition.

Ans : (B)

In this model, the shells represent discrete stationary states where energy increases with distance from the nucleus. Shell R is farther from the nucleus than shell P, meaning it possesses higher energy. Consequently, an electron must absorb a fixed amount of energy to transition from the lower energy level to the higher one.

20. Based on the provided schematic of an atom, identify the correct mass number and atomic number for this specific element.
- (A) Mass number 3, Atomic number 4
 (B) Mass number 4, Atomic number 3
 (C) Mass number 7, Atomic number 3
 (D) Mass number 7, Atomic number 4

Ans : (C)

The atomic number equals the total count of protons, which is three in this diagram. The mass number is the sum of protons and neutrons located inside the nucleus. With three protons and four neutrons present, the total mass number is seven. Electrons do not contribute significantly to the atomic mass.

21. The diagram depicts the electronic configuration of a neutral atom. What is the valency of this element based on the arrangement of its subatomic particles?
- (A) 2
 (B) 4
 (C) 6
 (D) 8

Ans : (B)

The atom contains fourteen electrons distributed across three shells, yielding an electronic configuration of 2, 8, 4. The outermost shell holds four valence electrons. To achieve a stable octet configuration, this element can share these

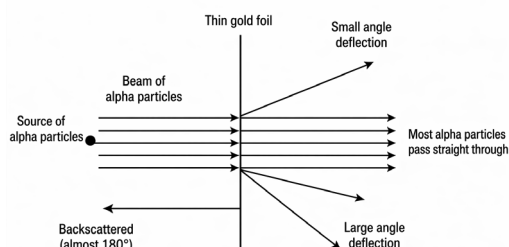
the nucleus like planets, they would constantly lose kinetic energy due to this acceleration. Consequently, their orbital paths would progressively shrink into an inward spiral, eventually causing them to crash directly into the positively charged nucleus, thereby destroying the atom's stability.

59. Describe the discovery of the neutron and explain its essential role within the atomic nucleus.

Ans :

The neutron was successfully discovered by James Chadwick in 1932. He identified a previously unknown subatomic particle located in the nucleus that possessed a mass nearly equal to that of a proton but carried absolutely no electrical charge. Neutrons play an incredibly crucial role in the atomic nucleus by actively reducing the intense electrical repulsion that exists between the tightly packed, positively charged protons. By adding necessary mass and creating strong binding forces, neutrons help hold the nucleus securely together, preventing disintegration.

60. Study the given schematic diagram.



What was the purpose of using an extremely thin gold foil? Why did a very small fraction of alpha particles deflect completely backwards?

Ans :

Ernest Rutherford specifically chose a gold foil because he needed an incredibly thin layer, about one thousand atoms thick, to observe the alpha particles passing through without undergoing multiple confusing collisions. The rare, complete 180-degree backward deflection of a few alpha particles occurred because they collided directly with a massive repulsive force. This crucial observation indicated that the entire positive charge and almost all the physical mass of the gold atom were densely concentrated in a tiny central region called the nucleus.

61. What is the atomic number of an element? How does it differ from the mass number in terms of subatomic particles?

Ans :

The atomic number of an element is exactly equal to the total number of positively charged protons inherently present in the nucleus of its atoms. It permanently defines the chemical identity of that element. In contrast, the mass number is the combined sum of both protons and neutrons, collectively known as nucleons, located inside the central nucleus. While the atomic number strictly dictates the electron count and chemical behavior, the mass number accounts for nearly the entire physical weight of the atomic structure.

62. Why is the maximum number of electrons in the outermost shell of an atom strictly limited to 8, even if the general formula allows for a higher capacity?

Ans :

According to the established Bohr-Bury rules, the outermost shell of any atom can accommodate a maximum of exactly 8 electrons, regardless of the higher capacity calculated by the general formula. This fundamental limitation is directly tied to atomic stability. Possessing exactly 8 electrons in the outermost valence shell constitutes an octet configuration, which makes the atom exceptionally stable and chemically inert, much like noble gases. Any configuration extending beyond 8 electrons in this boundary layer would create instability and is naturally prohibited.

63. Explain the concept of valency with reference to the octet rule, using sodium and oxygen as examples.

Ans :

Valency represents the chemical combining capacity of an element, determined strictly by the number of electrons it must lose, gain, or share to successfully achieve a stable octet configuration. For instance, sodium has an atomic number of 11, giving it an electronic arrangement of 2, 8, 1. It easily loses its one valence electron to achieve perfect stability, resulting in a valency of 1. Conversely, oxygen, with a configuration of 2, 6, needs to gain two electrons to complete its octet, giving it a valency of 2.

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- 29.** What was the unexpected result when alpha particles hit the gold foil in Rutherford's experiment?

Ans :

While most alpha particles passed straight through the gold foil, a few were sharply deflected, and a very small fraction completely bounced back.

- 30.** Why did Rutherford conclude that most of the space inside an atom is empty?

Ans :

Rutherford concluded this because the vast majority of alpha particles passed straight through the thin gold foil without experiencing any deflection from their path.

- 31.** What was the major limitation of Rutherford's planetary model of the atom?

Ans :

It failed to explain atomic stability because an accelerating electron should continuously lose energy, spiraling into the nucleus and causing the atom to collapse.

- 32.** How did Niels Bohr's model solve the problem of atomic stability?

Ans :

Bohr suggested that electrons revolve around the nucleus in fixed circular orbits called stationary states, where they absolutely do not lose any energy.

- 33.** What is the scientific term used for the fixed circular paths around the nucleus in Bohr's model?

Ans :

The fixed circular paths where electrons continually revolve around the central nucleus without radiating energy are formally called energy levels or atomic shells.

- 34.** Who discovered the neutron, and what is its electrical charge?

Ans :

James Chadwick successfully discovered the neutron in nineteen thirty-two, and it is a neutral subatomic particle carrying absolutely no electrical charge whatsoever.

- 35.** State one characteristic property of a neutron regarding its mass compared to other subatomic particles.

Ans :

A neutron possesses a mass that is nearly equal to that of a proton, making it significantly heavier than a tiny, lightweight electron.

- 36.** What is the full form of the abbreviation IUPAC in the context of chemistry?

Ans :

The full form of IUPAC is the International Union of Pure and Applied Chemistry, which officially approves the names and symbols of elements.

- 37.** Give one rule for writing the chemical symbol of an element if it has two letters.

Ans :

When a chemical symbol consists of two letters, the first letter is always uppercase while the second letter is strictly written in lowercase.

- 38.** What is meant by the atomic number of an element?

Ans :

The atomic number of an element is specifically defined as the total number of positively charged protons present inside the atom's central nucleus.

- 39.** Write the formula used to calculate the mass number of an atom.

Ans :

The mass number of an atom is directly calculated by adding the total number of protons and the total number of embedded neutrons.

- 40.** Define nucleons in the context of atomic structure.

Ans :

Nucleons essentially refer to the subatomic particles, specifically the protons and neutrons, which are packed tightly together inside an atom's central nucleus.

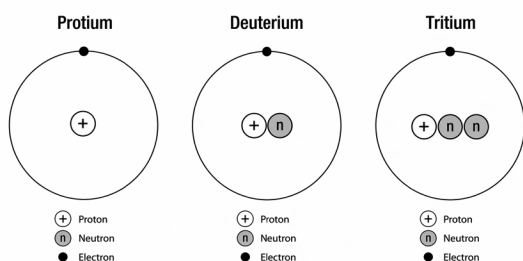
- 41.** What formula is used to find the maximum number of electrons in an energy shell?

Ans :

The maximum number of electrons that can be easily accommodated in any given energy shell

isotope of cobalt is highly effective in targeted radiation therapy for safely treating malignant cancers. Furthermore, the powerful isotope Uranium-235 is strategically used as a potent fuel inside nuclear reactors to sustainably generate massive amounts of industrial electrical energy.

69. Study the given diagrams of three related atomic species.



Identify the specific relationship between these three chemical species. Why do they exhibit identical chemical properties despite having distinct physical mass numbers?

Ans :

These three uniquely illustrated species represent the naturally occurring isotopes of hydrogen: protium, deuterium, and tritium. Isotopes are atoms belonging to the exact same element that share identical atomic numbers but possess varying mass numbers due to differing neutron counts. Despite their noticeably different physical masses, these isotopes demonstrate entirely identical chemical properties. This phenomenon occurs because chemical behavior is strictly governed by the number of valence electrons. Since all three isotopes retain exactly one electron, their combining capacities remain perfectly identical.

70. Compare protons and electrons strictly on the basis of their relative electrical charge, relative physical mass, and specific physical location within the atomic structure.

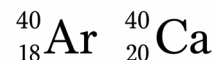
Ans :

Protons and electrons are fundamental subatomic particles that critically differ in charge, mass, and location. A proton inherently carries a positive relative electrical charge of +1, whereas an electron possesses an equal but profoundly opposite negative charge of -1. Regarding mass, a single proton is massively heavier, roughly 2000 times heavier than an exceedingly light electron, whose mass is considered entirely negligible.

Structurally, heavy protons are tightly bound deep inside the dense nucleus, while tiny electrons constantly revolve around it in vast orbits.

71. Draw the standard atomic notation for Argon (Atomic number 18, Mass number 40) and Calcium (Atomic number 20, Mass number 40). Explain why they are classified as isobars.

Ans :



Argon and calcium are strictly classified as isobars because they represent atoms of entirely different elements that possess uniquely different atomic numbers but coincidentally share the exact same mass number. The atomic number of argon is 18, whereas calcium is 20, meaning their chemical properties profoundly differ. However, the total cumulative sum of heavy nucleons, which includes both protons and neutrons residing together in their respective central nuclei, perfectly equals 40 for both atoms, granting them identical overall physical masses.

72. What exactly is the octet rule? Why are noble gases like helium and neon considered highly chemically unreactive in nature?

Ans :

The octet rule dictates that atoms physically reach their state of maximum stability when their outermost electron shell becomes completely occupied with exactly eight valence electrons. Atoms relentlessly strive to achieve this perfect state by actively losing, gaining, or sharing electrons. Noble gases like helium (with 2 electrons completing its only shell) and neon (with a perfect 8) inherently possess these fully saturated valence shells naturally. Because their combining capacity is literally zero, they absolutely do not need to chemically react, remaining permanently inert.

73. What are valence electrons? How does the count of these electrons directly dictate whether an atom will lose, gain, or share electrons during a reaction?

Ans :

Valence electrons are the specific electrons actively present in the outermost energy shell

SHORT ANSWER QUESTIONS

54. Explain Acharya Kanada's concept of 'parmanu' and how it relates to the modern idea of an atom.

Ans :

Acharya Kanada proposed that if we continuously divide matter, which he called dravya, we ultimately reach an indivisible stage of tiny particles called parmanus. He noted these particles are infinitely small and invisible to our senses. They naturally combine in pairs or trios to form the entire material universe. This ancient philosophical idea closely parallels the modern scientific concept of atoms, later introduced by John Dalton, which also defines atoms as the fundamental, indivisible building blocks of matter that combine to create physical substances.

55. What are cathode rays? How did J.J. Thomson's study of these rays lead to the discovery of electrons?

Ans :

Cathode rays are distinct streams of invisible, negatively charged particles observed travelling inside a low-pressure glass tube subjected to extremely high voltage. By applying electric and magnetic fields, J.J. Thomson observed that these rays deflected towards positive fields. He deduced that these rays consisted of tiny, negatively charged subatomic particles that were significantly smaller than atoms. Because these particles behaved exactly the same regardless of the gas or electrode material used, Thomson successfully concluded that electrons are fundamental constituents of every atom.

56. Explain the main postulates of Rutherford's planetary model of an atom derived from the gold foil experiment.

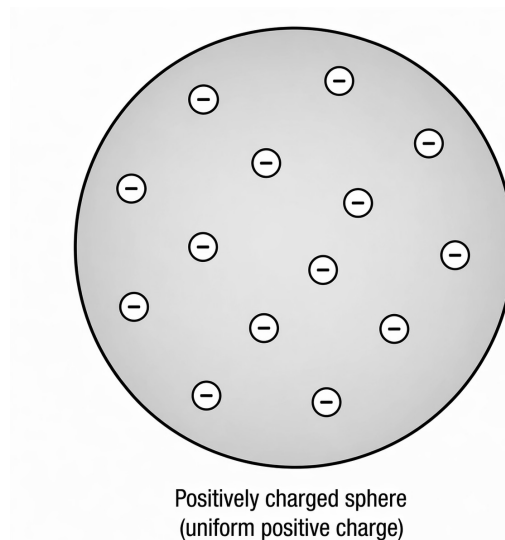
Ans :

Based on his revolutionary alpha-particle scattering experiment, Rutherford proposed the nuclear model of the atom. He firmly concluded that an atom consists of a tiny, dense, positively charged center called the nucleus, where almost the entire atomic mass is concentrated. Because most alpha particles passed straight through, he deduced that most of the space inside the atom is completely empty. Furthermore, he suggested that the negatively charged electrons revolve

rapidly around this central nucleus in well-defined circular paths, much like orbiting planets.

57. Draw a labelled diagram of Thomson's model of an atom. Explain how this model accounts for the electrical neutrality of an atom.

Ans :



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According to J.J. Thomson's atomic model, an atom is fundamentally composed of a uniform sphere of positive charge, with tiny negatively charged electrons embedded randomly throughout it, much like seeds scattered in a watermelon. To explain electrical neutrality, Thomson proposed that the total magnitude of the positive charge in the entire sphere is exactly equal to the total negative charge of all the embedded electrons combined. Because these opposite charges perfectly balance each other out, the atom remains electrically neutral overall.

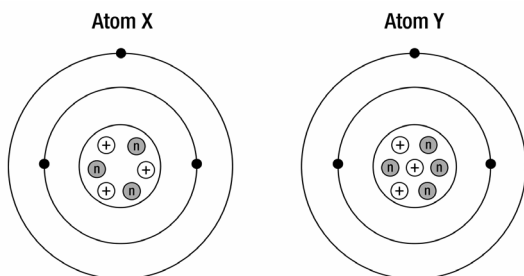
58. Assertion: According to Rutherford's model, an atom should eventually collapse and lose its stability. Is this claim scientifically correct? Justify your answer using the concept of charged particles in motion.

Ans :

Yes, this claim is scientifically correct regarding Rutherford's early model. According to the established laws of physics, any charged particle moving continuously in a circular path undergoes constant acceleration and must continuously radiate energy. If electrons were to revolve around

four electrons with other atoms. Therefore, its combining capacity, or valency, is exactly four.

22. Based on the internal structures of Atom X and Atom Y shown in the diagram, which statement accurately describes their relationship and chemical behavior?



- (A) They are isobars because they possess identical total numbers of nucleons.
 (B) They are atoms of entirely different elements with unique chemical properties.
 (C) They are isotopes of the same element and exhibit identical chemical properties.
 (D) They represent a single atom undergoing a structural change in its valency.

Ans : (C)

Both atoms possess three protons, meaning they share the same atomic number and belong to the same element. Because their outermost shells hold identical numbers of valence electrons (one), their combining capacity and chemical properties are the same. They are isotopes because they differ only in their number of neutrons.

23. The diagram illustrates three distinct atomic species of the same element, marked as Atom X, Atom Y, and Atom Z. Which fundamental characteristic is responsible for their identical chemical properties despite their differing masses?
- (A) They contain an identical number of neutrons in their respective nuclei.
 (B) They possess the same number of valence electrons in their outermost shell.
 (C) They have an equal sum of protons and neutrons in their central nuclei.
 (D) They exist in the same physical state at standard room temperature.

Ans : (B)

These atoms are isotopes, sharing the same atomic number but possessing different mass numbers due to varying neutron counts. Chemical properties

are determined primarily by the electronic configuration, specifically the number of valence electrons. Since all three species have exactly one electron, they exhibit identical chemical behavior and combining capacity.

VERY SHORT ANSWER

24. Who first proposed the concept of indivisible particles called 'parmanu' in ancient India?

Ans :

Acharya Kanada, an ancient Indian philosopher, first proposed that continuously dividing matter ultimately yields tiny indivisible particles which he specifically named parmanu.

25. Define Dalton's atomic theory regarding the composition of matter.

Ans :

Dalton's atomic theory proposed that all matter is composed of extremely small, fundamental, and indivisible building blocks widely known as atoms.

26. What caused scientists to reconsider the idea that atoms are the smallest indivisible units of matter?

Ans :

The discovery of radioactivity, where certain elements emit invisible energy and particles, clearly proved that atoms are actually composed of smaller subatomic particles.

27. Describe J.J. Thomson's plum pudding model of the atom in one sentence.

Ans :

Thomson proposed that an atom is a positively charged uniform sphere with negatively charged electrons embedded throughout it like plums inside a pudding.

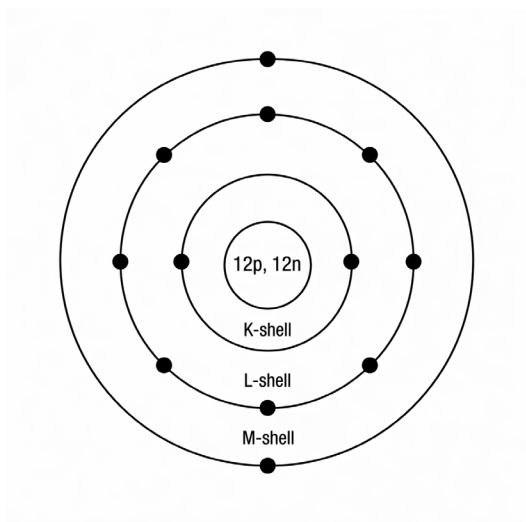
28. Which material did Ernest Rutherford use in his alpha particle scattering experiment?

Ans :

Ernest Rutherford used a very thin gold foil and directed a narrow beam of highly energetic alpha particles at it during his famous experiment.

64. Draw the schematic atomic structure of a magnesium atom (Atomic number 12, Mass number 24). Explain how its valency is determined from this electronic arrangement.

Ans :



Magnesium inherently possesses 12 electrons. Following standard distribution rules, these electrons densely populate the energy shells sequentially as 2 in the inner K-shell, 8 in the middle L-shell, and exactly 2 in the outermost M-shell. This specific arrangement clearly leaves 2 valence electrons on the periphery. Because it requires significantly less energy for a magnesium atom to completely lose these two electrons to uncover a stable underlying octet rather than gaining six more, its functional chemical valency is definitively determined to be 2.

65. What was John Dalton's early contribution to element symbols? How are symbols officially written today according to international standards?

Ans :

John Dalton was the first pioneer to introduce a standardized set of unique pictorial symbols to visually represent different chemical elements, such as drawing a circle with a central dot for hydrogen. Today, symbols are globally approved by the International Union of Pure and Applied Chemistry and utilize specific alphabets instead of pictures. These modern symbols typically consist of the first one or two letters of an element's name, ensuring the first letter is always capitalized while the second remains in lowercase.

66. Why do positively charged protons securely packed together inside an atomic nucleus not violently push each other apart due to powerful electrostatic repulsion?

Ans :

Positively charged protons naturally exert a powerful electrostatic repulsive force against one another, especially when packed closely. However, the atomic nucleus does not violently fly apart because it critically contains neutral particles called neutrons. These uncharged neutrons effectively physically intervene between the protons, slightly increasing the distance between them to diminish the repulsive electrostatic forces. More importantly, their presence helps generate the overwhelmingly strong nuclear force, a unique binding energy that aggressively overpowers electrical repulsion and holds the entire nucleus tightly together.

67. Assertion: The simple arithmetic mean of the masses of an element's isotopes always equals its true average atomic mass. Do you agree? Justify your stance using chlorine as an example.

Ans :

No, I strongly disagree with this assertion. Calculating a simple arithmetic mean is mathematically incorrect because naturally occurring isotopes almost never exist in perfectly equal proportions in nature. Therefore, scientists must calculate a precise weighted average based on their actual relative environmental abundances. For instance, naturally occurring chlorine consists of Cl-35 (about 75% abundance) and Cl-37 (about 25%). While a simple average wrongly yields 36 u, mathematically factoring in these unequal percentage ratios accurately produces a fractional average mass of exactly 35.5 u.

68. Isotopes frequently possess special properties that make them highly valuable. Explain three critical applications of specific radioactive isotopes across different modern fields.

Ans :

Certain radioactive isotopes exhibit highly specialized properties that make them exceptionally useful across diverse modern fields, particularly medicine and energy. For example, a specific isotope of iodine is medically utilized to accurately diagnose and treat dangerous thyroid disorders like goitre. Similarly, the radioactive

is formally determined by the formula $2n^2$.

- 42.** What would be the maximum number of electrons in the M-shell according to the Bohr-Bury rules?

Ans :

According to the Bohr-Bury rules, the M-shell represents the third energy level, so it can ultimately accommodate a maximum of eighteen electrons.

- 43.** State the condition required for an atom to have electrons in the L-shell.

Ans :

Electrons will genuinely begin to occupy the L-shell only after the innermost K-shell has been completely filled with its maximum capacity of two electrons.

- 44.** What are valence electrons in an atom?

Ans :

Valence electrons are the specific negatively charged particles that are present in the outermost energy shell and primarily determine an atom's chemical properties.

- 45.** Define valency in terms of an atom's combining capacity.

Ans :

Valency is clearly defined as the exact number of electrons an atom must strictly lose, gain, or share to achieve a stable outermost shell.

- 46.** What is the significance of an atom having eight electrons in its outermost shell?

Ans :

An atom containing exactly eight electrons in its outermost shell possesses a complete octet, making it highly stable and generally chemically unreactive.

- 47.** State one major difference between isotopes of the same element.

Ans :

While isotopes of the same element consistently share identical atomic numbers, they possess distinctly different mass numbers due to differing neutron counts.

- 48.** State one similarity among all the naturally occurring isotopes of hydrogen.

Ans :

All naturally occurring isotopes of hydrogen strictly contain exactly one proton in their central nucleus and share the identical atomic number of one.

- 49.** Give one practical application of the radioactive isotope of cobalt.

Ans :

The highly radioactive isotope of cobalt, specifically known as cobalt-sixty, is widely utilised in the medical field for targeted radiation treatments against cancer.

- 50.** Why do the chemical properties of isotopes of a particular element remain identical?

Ans :

Chemical properties depend entirely upon the specific number of valence electrons, which perfectly remains the exact same across all different isotopes of an element.

- 51.** Why is the atomic mass of chlorine considered to be a fractional value of 35.5 u?

Ans :

The atomic mass is fractional because it accurately represents the weighted average mass of chlorine's two naturally occurring isotopes based on their relative abundances.

- 52.** Define isobars with respect to different elements.

Ans :

Isobars are clearly defined as atoms belonging to completely different chemical elements that share the exact same mass number despite having differing atomic numbers.

- 53.** Give one example of a pair of elements that are classified as isobars.

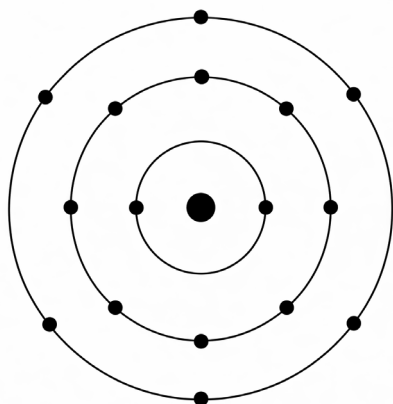
Ans :

Calcium and argon perfectly serve as a classic example of isobars since both uniquely possess a mass number of forty despite distinct atomic numbers.

of any given atom. They exclusively dictate the chemical reactivity and total combining capacity of the element. If an atom possesses fewer than four valence electrons, it inherently prefers losing them to uncover a stable underlying octet. Conversely, if an atom has more than four, it energetically prefers gaining external electrons to quickly complete its octet. Elements possessing exactly four valence electrons typically share them to achieve necessary stability.

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74. Study the given schematic diagram of an atom's electron distribution.



Identify the element based on its atomic number. What is its chemical valency, and how exactly will it achieve a stable electronic configuration?

Ans :

By carefully counting the total electrons visually distributed across the shells (2 in the inner, 8 in the middle, and 7 in the outer), we determine the atomic number is exactly 17, uniquely identifying the element as chlorine. Because chlorine inherently possesses 7 valence electrons on its outermost periphery, it desperately needs only one additional electron to perfectly complete its noble-gas octet. Therefore, its chemical valency is exactly 1. It readily achieves ultimate stability by forcefully gaining or mutually sharing this required electron.

75. Trace the historical sequence of scientific atomic models, briefly highlighting the major structural improvement each successive model successfully brought over the previous one.

Ans :

The conceptual journey began with Dalton boldly proposing the atom as a solid, indivisible particle. Later, Thomson discovered electrons and introduced the plum pudding model, suggesting negative particles were merely embedded in a positive sphere. Rutherford's foil experiment famously shattered this, revealing a dense central positive nucleus surrounded by randomly orbiting electrons in vast empty space. Finally, Niels Bohr significantly refined this architecture by introducing fixed energy levels, proving that electrons revolve only in discrete stationary shells, thereby successfully explaining permanent atomic stability.

76. Chlorine naturally occurs as two distinct isotopes, Cl-35 and Cl-37, in an approximate ratio of 3:1. Calculate its average atomic mass and briefly explain what this value implies.

Ans :

Chlorine fundamentally consists of Cl-35 with a natural abundance of 75%, and Cl-37 with a smaller abundance of 25%. Its average atomic mass is carefully calculated using these specific weighted proportions: $(35 \times 75/100) + (37 \times 25/100) = 26.25 + 9.25 = 35.5 \text{ u}$. This unique fractional value practically implies that while no single chlorine atom physically weighs exactly 35.5 u, any macroscopic sample of naturally occurring chlorine gas will universally behave chemically and physically as if this is its uniform mass.

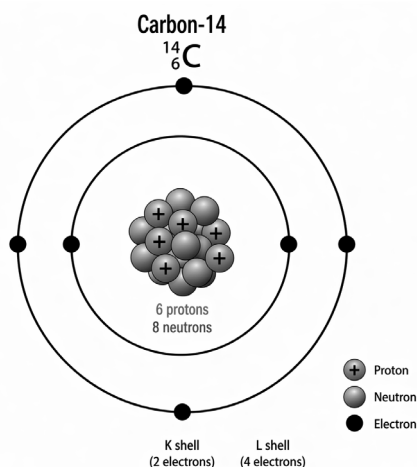
77. What subatomic balance precisely makes an atom electrically neutral? How does this internal balance drastically change when a metallic atom loses a valence electron?

Ans :

An ordinary atom remains electrically neutral because the total count of positively charged protons firmly locked inside the central nucleus perfectly equals the total count of negatively charged electrons rapidly orbiting outside. These identically opposite charges flawlessly cancel each other's effects. However, when a metallic atom deliberately loses an outer valence electron to comfortably achieve octet stability, this delicate internal balance is permanently disrupted. The atom suddenly possesses more protons than electrons, instantly transforming the formerly neutral entity into a positively charged ion.

78. Draw the fundamental atomic structure for the radioactive Carbon-14 isotope. Briefly explain how its central nucleus specifically differs from the most common abundant isotope, Carbon-12.

Ans :



The radioactive Carbon-14 isotope holds an atomic number of 6, meaning it naturally possesses exactly 6 electrons revolving around a nucleus containing precisely 6 protons and 8 neutrons. In direct contrast, the highly abundant Carbon-12 isotope also contains 6 protons and 6 electrons, seamlessly ensuring identical chemical behaviour across both forms. However, its nucleus contains only 6 neutrons. Therefore, Carbon-14 fundamentally differs by containing two additional heavy neutrons, slightly increasing its physical mass and actively rendering this specific isotope physically unstable and radioactive.

79. What exactly are subatomic nucleons? How is an element's overall mass number mathematically calculated from the total count of these specific particles?

Ans :

Nucleons are the relatively heavy, fundamental subatomic particles that permanently reside exclusively within the microscopic, extremely dense central core of an atom known as the atomic nucleus. This highly specific group strictly includes both the positively charged protons and the electrically uncharged neutrons. Because the rapidly orbiting electrons possess a virtually non-existent mass, essentially the entire physical weight of an atom originates here. Consequently, the mass number is mathematically calculated by

simply adding the total number of constituent protons to the total neutrons.

80. Explain the standard scientific notation utilized to represent an element's symbol, mass number, and atomic number simultaneously. Illustrate this by writing the precise notation for phosphorus (15 protons, 16 neutrons).

Ans :

In standard chemistry, a highly specific notation is universally utilized to compactly convey crucial subatomic information about an element simultaneously. The recognized chemical symbol is written clearly in the center. The atomic number, directly representing the exact proton count, is written as a numerical subscript on the lower left side. The mass number, representing total heavy nucleons, is written as a superscript on the upper left. For phosphorus, containing 15 protons and 16 neutrons (making the mass 31), the notation is precisely written as $^{31}_{15}\text{P}$.

81. Compare the distinct concepts of isotopes and isobars specifically with respect to atomic number, overall mass number, and resulting chemical properties, providing one clear example of each.

Ans :

Isotopes are atoms belonging to the exact same element, meaning they share identical atomic numbers but display different mass numbers due to varying neutrons. Because their electron counts match perfectly, their chemical properties remain identical, like naturally occurring Chlorine-35 and Chlorine-37. Conversely, isobars are atoms belonging to completely different elements that unexpectedly share identical mass numbers but possess differing atomic numbers. Consequently, isobars like Calcium-40 and Argon-40 exhibit entirely unique chemical properties, as they inherently belong to separate positions on the periodic table.

82. Assertion: The physical mass of an atom is almost entirely and exclusively concentrated within its central nucleus. Is this statement scientifically accurate? Justify your answer based on subatomic particles.

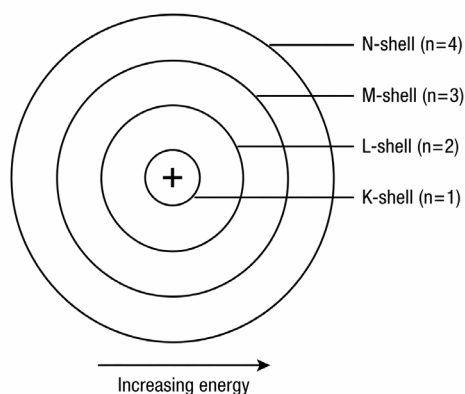
Ans :

Yes, this statement is considered thoroughly scientifically accurate for all practical chemistry and physics purposes. An ordinary atom fundamentally consists of protons, neutrons, and electrons. Protons and neutrons are massive, heavy particles

firmly located exclusively inside the central atomic nucleus. In stark contrast, an electron is exceedingly tiny, possessing a mass roughly 2000 times smaller than a single proton. Because the electrons' cumulative contribution to the weight is negligible, over 99.9% of the atom's entire physical mass resides directly within the nucleus.

83. Draw a diagram showing the energy levels in an atom according to Bohr's model. How did Bohr's introduction of stationary states resolve the fatal limitation of Rutherford's model?

Ans :



Rutherford's model critically failed to explain atomic stability because revolving electrons would theoretically lose energy and spiral into the nucleus. Niels Bohr resolved this anomaly by postulating that electrons revolve only in special, fixed circular paths called discrete stationary orbits. While moving inside these allowed energy levels, electrons naturally do not radiate or lose any energy. An electron's total energy remains completely constant as long as it stays in its specific shell, brilliantly ensuring the atom remains structurally stable forever.

LONG ANSWER QUESTIONS

84. (a) Explain the major limitation of Rutherford's atomic model regarding atomic stability.
(b) How did Niels Bohr overcome this limitation in his atomic model?

Ans :

- (a) The primary limitation of Rutherford's planetary model was its inability to explain the stability of an atom. According to

classical physics, any charged particle moving in a circular path undergoes continuous acceleration and must radiate energy. Therefore, revolving electrons should constantly lose energy, causing their orbits to shrink until they spiral into the nucleus, making the atom highly unstable and prone to collapse.

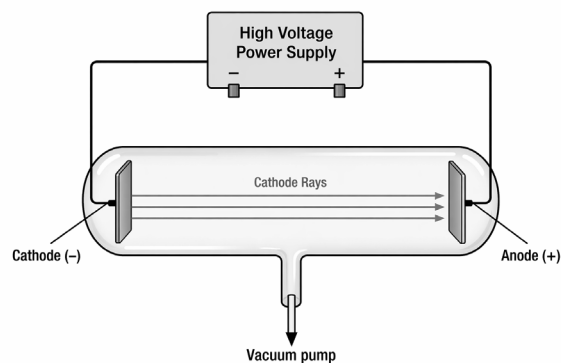
- (b) Niels Bohr resolved this flaw by proposing that electrons do not radiate energy while moving around the nucleus. He postulated that electrons revolve only in certain special, permitted circular paths called discrete orbits or energy levels, represented by K, L, M, and N shells. As long as an electron remains in a specific stationary orbit, its energy remains constant. Electrons only absorb or emit fixed amounts of energy when jumping between these designated energy levels.

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85. (a) Describe J.J. Thomson's cathode ray experiment with a suitable diagram.
(b) What was the major conclusion drawn from this experiment regarding the nature of atoms?

Ans :

- (a)



Thomson used a glass tube containing gas at very low pressure with two electrodes. He applied a high voltage, creating cathode rays that travelled from the negative cathode to the positive anode. By applying electric and magnetic fields, he observed these rays deflecting, proving they consisted of negatively charged particles much smaller than atoms. This ground breaking experiment led to the discovery of electrons.

- (b) Consequently, Thomson concluded that atoms are not indivisible units of matter as previously believed, but contain fundamental subatomic components. Since electrons are negatively charged and the atom is electrically neutral, he later inferred the presence of a positive charge to balance the electrons. This discovery revolutionized atomic theory, marking the transition from Dalton's solid sphere to complex atomic models.

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86. (a) Differentiate between atomic number and mass number.
(b) An element has an atomic number of 13 and a mass number of 27. Determine its number of protons, neutrons, and electrons.
(c) What will be the valency of this element and why?

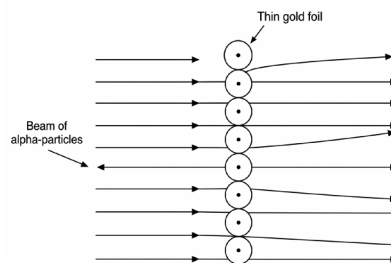
Ans :

- (a) The atomic number represents the total number of protons present in the nucleus of an atom, uniquely identifying the element. In contrast, the mass number is the sum of the total number of protons and neutrons located together in the nucleus.
(b) For the given element with an atomic number of thirteen, it possesses exactly thirteen protons. Since a neutral atom has an equal number of protons and electrons, it also contains thirteen electrons. The number of neutrons is calculated by subtracting the atomic number from the mass number, which gives fourteen neutrons.
(c) To find its valency, we determine its electronic configuration, which is two, eight, and three for the K, L, and M shells respectively. Since it has three valence electrons in its outermost shell, it tends to lose these three electrons to achieve a stable octet, resulting in a valency of three.

87. (a) Draw a schematic view of Rutherford's gold foil experiment.
(b) State the three major observations made during this experiment.
(c) How did these observations lead to the formulation of the planetary model of the atom?

Ans :

(a)



In Rutherford's alpha-ray scattering experiment, a beam of fast-moving alpha particles was directed at an extremely thin gold foil.

- (b) He observed that most alpha particles passed straight through without deflection, some were deflected by small angles, and a very small fraction bounced completely back.
(c) Based on these observations, Rutherford concluded that an atom is mostly empty space, explaining why most particles passed through freely. The deflection of some positively charged alpha particles indicated that the atom's positive charge is not spread uniformly but concentrated in a small, dense region. He termed this tiny central core the nucleus. The sharp rebounding of a few particles proved the nucleus holds almost all the atom's mass. Thus, he proposed the planetary model, where a central positive nucleus is surrounded by electrons revolving in circular orbits.

88. (a) Define isotopes and explain why they exhibit similar chemical properties but different physical properties.
(b) Chlorine occurs in nature as two isotopes of masses 35 u and 37 u in the ratio of 3:1. Calculate the average atomic mass of chlorine.

Ans :

- (a) Isotopes are defined as atoms of the same element that possess the identical atomic number but differ in their mass numbers due to a varying number of neutrons in their nuclei. Because chemical properties are solely determined by the number of valence electrons and their electronic configuration, isotopes of an element react identically in chemical reactions. However, their varying neutron counts give them different atomic masses,

resulting in distinct physical properties like boiling points and density.

- (b) To calculate the average atomic mass of naturally occurring chlorine, we use the relative abundances of its isotopes. The isotope with mass thirty-five constitutes seventy-five percent, while the isotope with mass thirty-seven constitutes twenty-five percent. The calculation is done by adding the product of thirty-five and seventy-five hundredths to the product of thirty-seven and twenty-five hundredths. This mathematical evaluation yields exactly thirty-five point five unified atomic mass units.

89. (a) Name the three fundamental subatomic particles of an atom and state their relative charges.
- (b) Which scientist discovered the neutron and why was it the last subatomic particle to be discovered?
- (c) Why do heavier atoms require significantly more neutrons compared to protons in their nucleus?

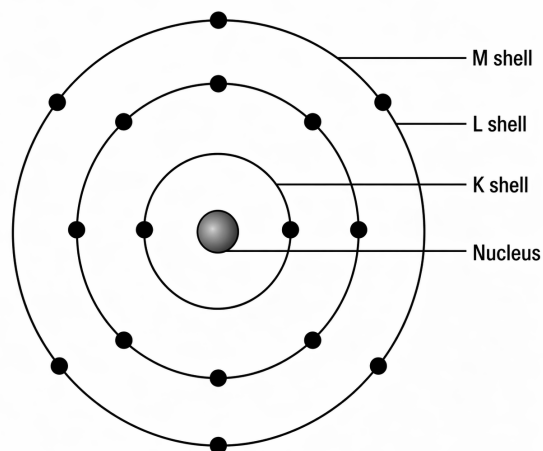
Ans :

- (a) The three fundamental subatomic particles constituting an atom are the negatively charged electron, the positively charged proton, and the electrically neutral neutron. Their relative charges are negative one, positive one, and zero, respectively.
- (b) James Chadwick discovered the neutron much later in the twentieth century. It remained undetected for a long time because, unlike protons and electrons, it possesses no electrical charge, rendering it unresponsive to the electric and magnetic fields used in early atomic experiments.
- (c) Neutrons play a crucial role in maintaining atomic stability, especially in heavier elements. Protons packed tightly within the tiny nucleus exert tremendous electrostatic repulsive forces on each other due to their identical positive charges. Neutrons mitigate this intense repulsion by increasing the distance between adjacent protons and providing additional strong nuclear force. Consequently, heavier nuclei demand a disproportionately higher number of neutrons to bind the completely unstable nucleus together.

90. (a) State the rules given by Bohr and Bury regarding the maximum number of electrons in different energy shells.
- (b) Write the electronic configuration of Sulphur with an atomic number of 16.
- (c) Draw a schematic atomic structure of Sulphur showing the arrangement of electrons.

Ans :

- (a) The Bohr-Bury scheme outlines specific rules for electron distribution. The maximum number of electrons accommodated in any shell is given by the formula $2n^2$, where n represents the orbit number. Consequently, the K shell holds up to two electrons, the L shell holds eight, and the M shell holds eighteen. Secondly, the outermost shell of an atom can accommodate a maximum of only eight electrons, regardless of its theoretical capacity. Finally, electrons fill shells in a strictly stepwise manner, meaning an inner shell must be completely filled before electrons begin occupying the next outward shell.
- (b) For the element sulphur, which has an atomic number of sixteen, the neutral atom contains exactly sixteen electrons. Following the established rules, its electronic configuration becomes two electrons in the first shell, eight in the second, and six remaining electrons in the outermost third shell.
- (c)



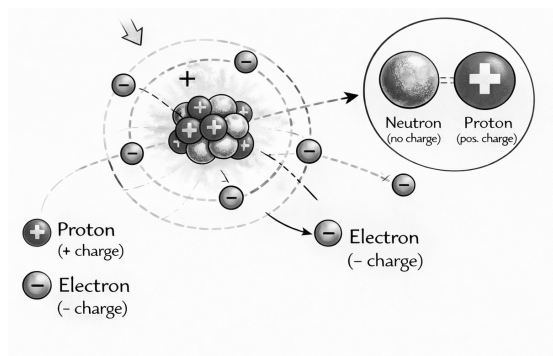
QUESTIONS:

- Which earlier atomic model failed to explain why revolving electrons do not spiral into the nucleus?
- Name the Danish physicist who solved this stability problem and state the term he used for these special designated paths.
- According to the new model, why doesn't an electron lose energy while revolving around the nucleus?
- How does the energy of an electron in the shell closest to the nucleus (K-shell) compare to the energy of an electron in a shell farther away (like the M-shell)?

Ans :

- Rutherford's planetary model of the atom failed to explain the stability of the atom and why electrons do not collapse into the nucleus.
- The Danish physicist was Niels Bohr. He called these special designated paths "stationary states," "orbits," or "energy levels."
- Bohr postulated that while moving in a specific fixed shell or stationary state, an electron does not radiate or lose energy, allowing the atom to remain perfectly stable.
- The energy of an electron in the K-shell (closest to the nucleus) is the least. The energy increases as we move away from the nucleus, so an electron in the M-shell has much higher energy than one in the K-shell.

- 104.** For a long time, it was thought that atoms were composed only of protons and electrons. However, the mass of most atoms (except hydrogen) was found to be more than what could be accounted for by protons alone. In 1932, James Chadwick discovered another subatomic particle residing in the nucleus, which had no charge and a mass nearly equal to that of a proton.

**NODIA**

- What is the name of this neutral subatomic particle discovered by James Chadwick?
- Where is this particle located within an atom?
- How does the mass of this particle compare to the mass of a proton and an electron?
- How did the discovery of this particle help explain the discrepancy in the atomic masses of elements?

Ans :

- The neutral subatomic particle is called a neutron.
- The neutron is located within the nucleus of an atom.
- The mass of a neutron is nearly equal to that of a proton and is approximately 2000 times the mass of an electron (the mass of an electron is considered negligible in comparison).
- The discovery of the neutron helped explain the actual atomic masses of elements, as the mass of an atom is the sum of the masses of protons and neutrons in its nucleus.

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- 105.** Dr. Aisha was reviewing a chemical analysis report of a newly synthesized material in her materials science lab. The readout highlighted two distinct elements that were crucial for the compound's strength. Element X had exactly 13 protons and 14 neutrons packed tightly in its central core. Element Y had an atomic number of 8 and a mass number of 16. She carefully logged these values into the computer, knowing that the dense central core of these atoms accounted for nearly all of the material's physical mass, while the lightweight particles buzzing in the outer shells were ignored in weight calculations.

QUESTIONS:

- What are the lightweight particles buzzing in the outer shells that Dr. Aisha considers negligible in weight calculations?
- Calculate the atomic number and mass number for Element X based on the lab report.
- Identify Element X and Element Y using their atomic numbers.
- Calculate the number of neutrons present in the nucleus of Element Y.
- Explain why the central core (nucleus) of the atoms accounts for nearly all of the material's physical mass.

NUMERICAL QUESTIONS

94. Find the number of neutrons in $^{31}\text{X}_{15}$?

Ans :

$$\begin{aligned} ^{31}\text{X}_{15} \text{ indicate that no. of proton} \\ &= 15 \text{ and mass number} = 31 \\ \text{Mass number} &= \text{No. of protons} \\ &+ \text{No. of neutrons} = 31 \\ \text{Number of neutrons} &= 31 - \text{number of protons} \\ &= 31 - 15 = 16 \end{aligned}$$

95. Helium atom has an atomic mass of 4u and two protons in its nucleus. How many neutrons it have?

Ans :

$$\begin{aligned} \text{Mass number} &= \text{Number of protons} \\ &+ \text{Number of neutrons} \\ 4 &= 2 + \text{No. of neutrons} \\ \text{Number of neutrons} &= 4 - 2 = 2 \end{aligned}$$

96. If K and L shells of an atom are full, then what would be the total number of electrons in the atom?

Ans :

$$\begin{aligned} \text{Number of electrons in full K-shell} &= 2 \\ \text{Number of electrons in full L-shell} &= 8 \\ \text{Total number of electrons in an atom} &= 2 + 8 = 10 \text{ electrons.} \end{aligned}$$

97. Chlorine occurs in nature in two isotopic forms with masses 35u and 37u in the ratio of 3 : 1. What should be the mass of chlorine atom?

Ans :

$$\begin{aligned} \text{The mass of chlorine atom is} \\ &= 35 \times \frac{75}{100} + 37 \times \frac{25}{100} \\ &= \frac{105}{4} + \frac{37}{4} \\ &= \frac{142}{4} = 35.5 \text{ u} \end{aligned}$$

CASE BASED QUESTIONS

98. During a school trip to the National Science Museum, Grade 9 students stumbled upon an ancient manuscript exhibit. The guide explained how a brilliant Indian philosopher thousands of years ago suggested that if we keep breaking a piece of jaggery, we will eventually reach a tiny, indivisible speck that cannot be seen with the naked eye. Next to it was a portrait of an English scientist who later proposed the first modern scientific theory stating all matter is made of these fundamental building blocks. The students were amazed to see how an ancient philosophical thought transformed into a scientific principle over centuries.

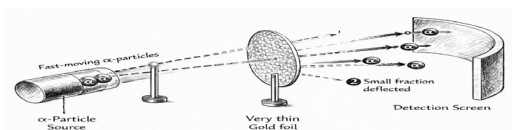
QUESTIONS:

- Name the ancient Indian philosopher mentioned in the scenario and the specific term he used for the smallest indivisible particles.
- Who was the English scientist that proposed the first scientific atomic theory in 1808 based on experimental observations?
- According to the scientific theory proposed in 1808, what is the fundamental characteristic of atoms regarding their divisibility?
- Why is the concept proposed by the ancient Greek and Indian philosophers considered an imaginary idea rather than a formal scientific theory?

Ans : :

- The ancient Indian philosopher was Acharya Kanada, and he called the smallest indivisible particles "parmanu".
- John Dalton was the English scientist who proposed the first scientific atomic theory.
- According to Dalton's atomic theory, atoms are indivisible particles, which means they are the fundamental building blocks of matter that cannot be broken down into smaller parts.
- The concepts proposed by ancient philosophers are considered imaginary ideas because they were based purely on profound thinking, intellectual reasoning, and philosophical debate, rather than on concrete scientific experiments or empirical evidence.

99. Scientists conducted an experiment where fast-moving alpha (α)-particles were directed at a very thin gold foil. They observed that most α -particles passed straight through the foil, a small fraction were deflected by small angles, and a very few (about 1 in 12000) bounced back. This experiment was crucial in understanding atomic structure.



1. Which model of the atom existing before this experiment would have predicted that most α -particles would pass through with very little deflection, but would not have easily explained the large-angle deflections or bouncing back?
2. What major conclusion did Rutherford draw from the observation that most α -particles passed straight through the gold foil?
3. What did the deflection of a few α -particles by small and large angles, and the bouncing back of very few α -particles, indicate about the distribution of positive charge and mass in the atom?
4. Name the subatomic particle that Rutherford's model proposed to be concentrated in a very small volume at the center of the atom.

Ans :

1. J.J. Thomson's "plum pudding" model, where positive charge was thought to be spread throughout the atom with electrons embedded in it, would have predicted minor deflections but not the significant deflections or rebounding observed.
2. Rutherford concluded that most of the space inside an atom is empty.
3. It indicated that the positive charge and most of the mass of the atom are concentrated in a very small volume within the atom (the nucleus), which repelled the positively charged α -particles when they came close.
4. Rutherford's model proposed that the positive charge and mass are concentrated in the nucleus, which contains protons.

100. At a summer picnic, Rohit was slicing a large, ripe watermelon for his friends. As he cut it open, he noticed the small black seeds scattered randomly throughout the sweet, red pulp. He immediately recalled a science lesson about early historical atomic models. He told his friends that a famous scientist once described the structure of an atom exactly like this sliced fruit to explain how positive and negative charges stay balanced. In his explanation, the entire red edible part represented a widespread electrical charge, while the seeds represented newly discovered subatomic components.

QUESTIONS:

- (a) Which scientist's atomic model is Rohit recalling while looking at the watermelon at the picnic?
- (b) In this real-life fruit analogy, what do the red pulp and the black seeds represent respectively in terms of subatomic structure?
- (c) If the atom as a whole is electrically neutral, what must be true about the magnitude of the charges represented by the red pulp and the seeds?

Ans :

- (a) Rohit is recalling J. J. Thomson's model of the atom.
- (b) In this analogy, the red pulp represents the positively charged sphere (positive charge spread evenly), and the black seeds represent the negatively charged electrons embedded within it.
- (c) For the atom to be electrically neutral, the total positive charge of the red pulp must be exactly equal in magnitude to the total negative charge of all the embedded seeds (electrons), balancing each other out perfectly.

Ananya and her team set up an interactive exhibit for the inter-school science fair. They created a highly magnified simulation of a famous 1911 atomic experiment. They fired a stream of high-speed, positively charged laser-guided particles at an incredibly thin golden foil. On the circular sensor screen placed behind the foil, most indicator lights flashed straight through the foil. However, a few lights flashed at wide angles, and very rarely, a particle seemed to bounce straight back towards the firing source. The visitors were shocked by the backward bounce, just like the original scientist was over a century ago.

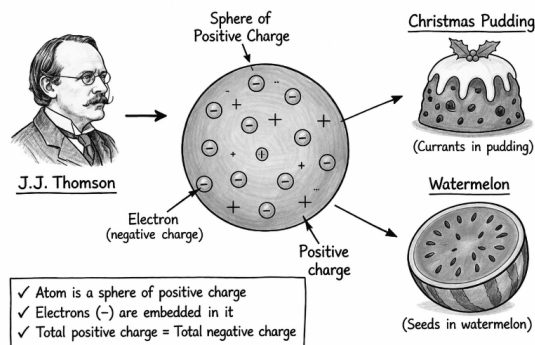
QUESTIONS:

- Identify the famous experiment being simulated by Ananya's team and the scientist who led this research.
- What are the specific high-speed, positively charged particles used in the actual historical experiment?
- What structural conclusion was drawn from the observation that most particles passed straight through the foil without any deflection?
- Why did a small fraction of the particles deflect at wide angles or bounce straight back?
- Based on the results of this experiment, how does the size of the central nucleus compare to the overall size of the atom?

Ans :

- The experiment being simulated is the gold foil experiment (or alpha-particle scattering experiment), led by Ernest Rutherford.
- The high-speed, positively charged particles used were alpha particles, which are essentially helium nuclei containing two protons and two neutrons.
- Since most alpha particles passed straight through the gold foil undeflected, it was concluded that most of the space inside an atom is empty.
- The wide-angle deflections and backward bounces occurred because the heavy, positively charged alpha particles directly hit or passed very close to the extremely dense, positively charged center of the atom called the nucleus, causing a strong repulsive force.
- Rutherford calculated that the nucleus is extremely small compared to the atom, estimating its radius to be about one lakh (10^5) times smaller than the radius of the entire atom.

- 102.** J.J. Thomson proposed a model of the atom, often likened to a Christmas pudding or a watermelon. He suggested that an atom consists of a sphere of positive charge with negatively charged electrons embedded within it, much like currants in a pudding or seeds in a watermelon. He also proposed that the negative and positive charges are equal in magnitude.



- According to Thomson's model, what was the overall charge of an atom? Why?
- How were the electrons arranged within the atom in Thomson's model?
- What was one major aspect of atomic structure that Thomson's model successfully explained?
- Why was Thomson's model eventually superseded by Rutherford's model?

Ans :

- According to Thomson's model, the overall charge of an atom was neutral. This was because he proposed that the negative charges (electrons) and the positive charges (sphere) were equal in magnitude, balancing each other out.
- In Thomson's model, the electrons were embedded within the sphere of positive charge.
- Thomson's model successfully explained that atoms are electrically neutral.
- Thomson's model was superseded because it could not explain the results of experiments like Rutherford's alpha-particle scattering experiment, particularly the large-angle deflections of alpha particles, which indicated a dense, centrally located positive charge.

- 103.** While watching a bicycle race on a circular track, Mr. Verma, a physics teacher, pointed out that cyclists get tired and lose energy as they continuously pedal around the tight curves. He asked his students to imagine an electron moving around a central nucleus in a similarly circular, accelerating path. He explained that classical physics predicted the electron would also lose energy, spiral inward, and eventually collapse. However, he noted that atoms are incredibly stable. This stability was finally explained by a revolutionary rule proposed by a Danish physicist who suggested electrons exist in special designated paths.

- 108.** Rahul and Maya were playing a strategic card game called “Chemical Connections.” Rahul drew a card for an element with atomic number 11, which gave him a single token in his outermost ring. Maya drew a card for an element with atomic number 17, leaving her with seven tokens in her outermost ring. To win the round, both players needed to achieve a highly stable configuration in their outermost shells. Rahul realized the fastest way to win was to permanently hand over his single token to Maya, allowing both of them to satisfy the game’s ultimate rule of stability.

QUESTIONS:

- Identify the elements that Rahul and Maya drew based on their given atomic numbers.
- What is the specific term used in chemistry for the stable configuration of eight electrons they are trying to achieve in their outermost shells?
- Determine the valency (combining capacity) of Rahul’s element and Maya’s element.
- Explain scientifically how Rahul giving away his one token helps his element become stable.

Ans :

- Rahul drew Sodium (Na) with atomic number 11. Maya drew Chlorine (Cl) with atomic number 17.
- The term for this stable configuration of eight electrons in the valence shell is an “octet”.
- The valency of Rahul’s element (Sodium) is 1, as it needs to lose one electron. The valency of Maya’s element (Chlorine) is also 1, as it needs to gain one electron.
- Sodium has an electronic configuration of 2, 8, 1. By giving away its single outermost electron (token), the original outermost shell is emptied, making the completely filled inner shell (with 8 electrons) its new outermost shell. This allows Sodium to achieve a stable octet configuration.

- 109.** Mrs. Sharma visited the oncology department for a specialized diagnostic scan and treatment of a tumor in her thyroid gland. The specialist prescribed a carefully measured dose of a radioactive substance in a liquid medium. The doctor explained to her that this substance is a special variant of a common dietary element. It behaves identically to the normal element during digestion and absorption, but because its nucleus contains extra neutrons, it safely emits helpful

radiation that specifically targets the diseased thyroid cells. Medical centers worldwide rely heavily on these unique atomic variants.

QUESTIONS:

- What is the scientific term for these atomic variants of the same element that have identical chemical properties but different numbers of neutrons?
- Which specific atomic variant is commonly used to treat goitre and thyroid cancer, as described in the medical scenario?
- State two other distinct examples of such atomic variants mentioned in your textbook and provide their specific real-world applications.

Ans :

- These atomic variants are called isotopes. They are atoms of the same element having the same atomic number but different mass numbers.
- The specific isotope used for the treatment of goitre and thyroid cancer is an isotope of iodine (Iodine-131).
- Two other examples are: an isotope of Uranium (U-235), which is used as a fuel in nuclear reactors to generate electricity, and an isotope of Cobalt (Co-60), which is used in radiation treatment for cancer. (Another acceptable answer is the isotope of carbon used in determining the age of ancient fossils).

- 110.** During a laboratory session on molecular weights, Aman was calculating the mass of common salt (sodium chloride). He checked the large periodic table poster on the wall and saw that the atomic mass of sodium was written as a whole number, 23. However, he was highly puzzled to see that the mass of chlorine was written as a decimal fraction: 35.5 u. He asked his teacher how it was physically possible for an atom to have half a neutron or proton. The teacher smiled and explained that this number is not the mass of a single atom, but rather a mathematical reflection of how nature mixes different variants of chlorine.

QUESTIONS:

- Why is it physically impossible for an individual chlorine atom to have a mass of exactly 35.5 u?
- In nature, what are the two naturally occurring isotopic forms of chlorine and what are their respective mass numbers?

Ans :

- The lightweight particles in the outer shells are electrons, which have almost negligible mass compared to protons and neutrons.
- For Element X, the atomic number is equal to the number of protons, which is 13. The mass number is the sum of protons and neutrons ($13 + 14$), which is 27.
- Element X with atomic number 13 is Aluminium (Al). Element Y with atomic number 8 is Oxygen (O).
- The number of neutrons in Element Y is calculated by subtracting the atomic number from the mass number ($16 - 8$), which equals 8 neutrons.
- The nucleus contains protons and neutrons (collectively called nucleons), which are much heavier particles. Since electrons have practically no mass, almost the entire mass of an atom is concentrated in the protons and neutrons packed within the small central nucleus.

- 106.** An event manager is organizing a large music concert in a circular indoor arena. The seating is strictly arranged in concentric circles expanding outward from the central stage. The innermost VIP circle is very small and can only hold a maximum of 2 chairs. The second circle can comfortably seat exactly 8 people, and the third expanding circle can seat up to 18 people. The manager realizes this specific layout perfectly matches a mathematical formula he learned in his high school chemistry class regarding how specific tiny particles are distributed around a central core in a stepwise manner.

QUESTIONS:

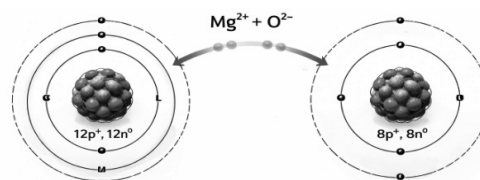
- What mathematical formula is the event manager recalling for the maximum distribution of electrons in energy shells?
- According to the rules governing this distribution, can the third seating circle begin filling up before the second circle is completely full? Explain based on atomic structure rules.
- If the venue represents a Silicon atom (atomic number 14), how many “people” (electrons) will be seated in the first, second, and third circles (K, L, and M shells) respectively?

Ans :

- The event manager is recalling the formula $2n^2$, where ‘n’ represents the shell number or energy level.

- No, the third circle cannot begin filling early. According to the Bohr-Bury rules, electrons are filled in shells in a stepwise manner. An outer shell (like the third circle) will only begin filling with electrons after the inner shells (first and second circles) are completely filled to their capacity.
- A Silicon atom has 14 electrons. Based on the rules, the distribution will be 2 electrons in the first circle (K-shell), 8 electrons in the second circle (L-shell), and the remaining 4 electrons in the third circle (M-shell). The configuration is 2, 8, 4.

- 107.** Magnesium (Mg) has an atomic number of 12. Oxygen (O) has an atomic number of 8. Atoms tend to achieve a stable octet in their outermost shell by gaining, losing, or sharing electrons, and this determines their combining capacity or valency.



- Write the electronic configuration of Magnesium (Mg, $Z=12$).
- How many electrons will Magnesium lose or gain to achieve a stable octet? What will be its valency?
- Write the electronic configuration of Oxygen (O, $Z=8$).
- How many electrons will Oxygen lose or gain to achieve a stable octet? What will be its valency?

Ans :

- Electronic configuration of Magnesium (12 electrons): $K=2, L=8, M=2$.
- Magnesium has 2 electrons in its outermost shell. It will lose these 2 electrons to achieve a stable octet in the L-shell. Its valency will be 2.
- Electronic configuration of Oxygen (8 electrons): $K=2, L=6$.
- Oxygen has 6 electrons in its outermost shell. It will gain 2 electrons to achieve a stable octet. Its valency will be 2 (determined by $8 - 6 = 2$).

91. (a) What do you understand by the term valency of an element? Explain how it is related to the octet rule.
- (b) Compare the valency of Oxygen with atomic number 8 and Magnesium with atomic number 12 based on their electronic configurations.

Ans :

- (a) Valency is defined as the combining capacity of an atom of an element to form chemical bonds with other atoms. This capacity is fundamentally governed by the octet rule, which states that atoms tend to gain, lose, or share valence electrons until their outermost shell contains exactly eight electrons, achieving a highly stable, noble gas-like electronic configuration. Elements with fewer than four valence electrons typically lose them, while those with more than four gain electrons to complete their octet.
- (b) Oxygen has an atomic number of eight, leading to an electronic configuration of two and six. Because it requires two additional electrons to complete its octet, its valency is two. In contrast, magnesium possesses an atomic number of twelve with a configuration of two, eight, and two. It readily loses its two outermost electrons to achieve stability, meaning magnesium also exhibits a valency of two.

92. (a) Define isobars with an example.
- (b) How do isobars fundamentally differ from isotopes in terms of their atomic structure?
- (c) State three practical applications of specific isotopes in the fields of medicine or industry.

Ans :

- (a) Isobars are atoms belonging to entirely different chemical elements that share the exact same mass number but possess distinctly different atomic numbers. A classic example involves argon and calcium. While argon has an atomic number of eighteen and calcium has an atomic number of twenty, both contain a total of forty nucleons, giving them identical mass numbers.
- (b) The fundamental structural difference is that isotopes consist of identical proton counts but varying neutron counts within a single element. Conversely, isobars feature entirely different proton and electron counts,

representing completely distinct chemical elements that just happen to share the same overall nucleon sum.

- (c) Isotopes possess diverse practical applications across various fields. A specific isotope of uranium serves as crucial fuel in nuclear power reactors to generate electricity. Additionally, an isotope of cobalt provides targeted radiation therapy for cancer treatments, and an iodine isotope effectively treats severe thyroid disorders.

93. (a) Describe the primary postulates of John Dalton's atomic theory regarding the indivisibility and mass of atoms.
- (b) How have modern scientific discoveries modified these specific postulates of Dalton's theory? Explain with examples.

Ans :

- (a) John Dalton proposed that all matter is composed of incredibly tiny, fundamental particles called atoms. His most significant postulates stated that atoms are the ultimate indivisible building blocks of matter that can neither be created nor destroyed. Furthermore, he asserted that all atoms belonging to a specific element possess perfectly identical mass and chemical properties.
- (b) However, subsequent modern scientific discoveries have profoundly modified these early ideas. The revelation of radioactivity and cathode rays proved that atoms are actually divisible, containing smaller subatomic entities like protons, neutrons, and electrons. The fundamental notion of identical atomic mass was also disproven by the discovery of isotopes. For instance, naturally occurring chlorine contains atoms with varying masses of thirty-five and thirty-seven units despite belonging to the same element. Consequently, while Dalton correctly identified atoms as chemical participants, their indivisible nature and mass uniformity are no longer considered scientifically valid.

- (c) What is the approximate percentage ratio in which these two isotopes occur naturally?
- (d) Explain briefly how the fractional value of 35.5 u is calculated using these natural abundances.

Ans :

- (a) An individual atom's mass is primarily determined by the total number of protons and neutrons (nucleons) in its nucleus. Since you cannot have a fraction of a proton or a neutron, an individual atom's mass number must always be a whole number.
- (b) The two naturally occurring isotopic forms of chlorine have mass numbers of 35 u and 37 u.
- (c) These isotopes occur in nature in a ratio of approximately 3:1, meaning the isotope with mass 35 constitutes about 75% and the isotope with mass 37 makes up about 25%.
- (d) The average atomic mass is calculated by finding the weighted average of the isotopes based on their abundance. It is calculated by multiplying the mass of each isotope by its percentage abundance and adding them together: $(35 \times 75/100) + (37 \times 25/100) = 26.25 + 9.25 = 35.5$ u.

- iii. In a university physics lab, researchers were comparing the physical properties of an inert gas stored in a pressurized glass tube and a highly reactive alkaline earth metal kept safely under oil. The gas was Argon, and the metal was Calcium. Despite having completely different chemical behaviors, different appearances, and differing numbers of protons (18 for the gas and 20 for the metal), the mass spectrometer readings showed an identical total nucleon count of 40 for both samples. The lead researcher noted that this specific pairing is a classic textbook example of distinct chemical elements sharing a common mass footprint.

QUESTIONS:

- (a) What specific scientific term is used to describe atoms of different elements that have different atomic numbers but the exact same mass number?
- (b) Identify the atomic number of the inert gas and the alkaline earth metal mentioned in the scenario.
- (c) Calculate the exact number of neutrons present in the atoms of both Argon and Calcium as described in this lab observation.

Ans :

- (a) The scientific term for atoms of different elements with different atomic numbers but the same mass number is "isobars."
- (b) The atomic number of the inert gas (Argon) is 18, and the atomic number of the alkaline earth metal (Calcium) is 20.
- (c) For Argon:
Mass number (40) - Atomic number (18)
= 22 neutrons.
For Calcium:
Mass number (40) - Atomic number (20)
= 20 neutrons.

112. Niels Bohr proposed a model of the atom to overcome the objections against Rutherford's model. Rutherford's model couldn't explain the stability of the atom, as revolving electrons should radiate energy and spiral into the nucleus. Bohr postulated that electrons revolve around the nucleus in certain special orbits called discrete orbits or energy levels, and while revolving in these discrete orbits, they do not radiate energy.
1. What was a major drawback of Rutherford's atomic model that Bohr's model attempted to address?
 2. What are the special orbits in Bohr's model called, and what happens to the energy of an electron when it is in one of these orbits?
 3. How are these orbits or shells designated (using letters and numbers)?
 4. According to Bohr's model, when would an atom be stable and less reactive?

Ans :

1. A major drawback of Rutherford's model was its inability to explain the stability of the atom; according to classical physics, an accelerating electron should radiate energy and fall into the nucleus.
2. The special orbits in Bohr's model are called discrete orbits or energy levels. While revolving in these discrete orbits, electrons do not radiate energy.
3. These orbits or shells are designated by the letters K, L, M, N,... or by the numbers $n=1, 2, 3, 4, \dots$
4. According to Bohr's model, if the atomic shells (especially the outermost shell) are complete (e.g., containing the maximum number of electrons they can hold, like an

4.5 Chemical Formula of a Compound

Using chemical formula, we get proportions of atoms that constitute a particular chemical compound by using single line of element symbols and their numbers. Other symbols like dashes, brackets and plus or minus signs are also there. These are limited to single typographic line of symbols, subscripts and superscripts, e.g., formula of water (H_2O), formula of sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$). In case molecules, the chemical formula is called molecular formula.

5. VALENCY

It is the combining capacity of an element (or its atom). It is expressed in terms of the number of hydrogen atoms or chlorine atoms or double the number of oxygen atoms that combine with one atom of that element, e.g., in ammonia (NH_3), the valency of N is 3 and in carbon dioxide (CO_2), the valency of C is 4.

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6. MOLECULAR MASS OF A SUBSTANCE

It is the mass of one molecule of that substance relative to $1/12$ th mass of an atom of carbon-12. It is also called molecular weight.

6.1 Calculation of Molecular Mass of a Compound

Molecular mass is the sum total of the atomic masses of all the atoms present in a molecule of that compound. It is obtained by multiplying the atomic mass of each element by the number of its atoms and then adding them together.

6.2 Gram Molecular Mass

It is molecular mass of a substance expressed in grams, e.g., gram molecular mass of $\text{H}_2\text{O} = 18 \text{ g}$.

6.3 Ions

An ion is an atom or a group of atoms carrying a charge. The valency of an ion is same as the charge carried by that ion.

1. Cation

The ions which carry positive charge are called cations, e.g., Na^+ (sodium ion), Mg^{2+} (magnesium ion), NH_4^+ (ammonium ion), etc.

2. Anion

The ions which carry negative charge are called anions, e.g., Cl^- (chloride ion), OH^- (hydroxide ion), SO_4^{2-} (sulphate ion), etc.

6.4 Steps Involved to write the Formula of a Molecular Compound

1. First of all, write symbols of constituent elements of the compound side-by-side such that less electronegative (more electropositive) element is on the left and more electronegative (less electropositive) element is on the right.
2. Write the valencies over symbols and then criss-cross them to write as subscripts to symbols.
3. If required, divide these numbers (subscripts) by a common factor.
4. If subscript is 1, it is not written in the final formula.

6.5 Steps Involved to write the Chemical Formula of an Ionic Compound

1. First of all, write the symbol (or chemical formula) of the cation showing charge on it, then the symbol (of chemical formula) of the anion showing charge on it, to the right of the cation.
2. If the compound has polyatomic ions, e.g., phosphate ion, then enclose the chemical formula of ion within small brackets and show the charge on it.
3. Crisscross the charge number (i.e., valency) of ions. So, cation is subscripted with charge of anion and anion is subscripted with charge of cation.
4. If required, divide subscripts by a common factor.
5. If subscript is 1, it is not written in the final formula.

7. MOLE OF A SUBSTANCE

It is that amount of the substance which contains the same number of entities (atoms, molecules, ions, electrons or photons, etc.) as there are atoms in exactly 12 g of pure C-12.

12 g of C-12 is found to contain 6.022×10^{23} atoms of carbon-12. The number 6.022×10^{23} is called Avogadro number or Avogadro constant. Thus, one mole is a collection of 6.022×10^{23} 'particles', be they atoms, molecules, ions, electrons, photons or anything.

electrons (which is equal to the number of protons in a neutral atom), and isotopes of the same element have the same number of protons and hence the same number of electrons.

- 116.** Consider two elements: Argon (Ar) and Calcium (Ca). Argon has an atomic number of 18. One common isotope of Argon has a mass number of 40. Calcium has an atomic number of 20. One common isotope of Calcium also has a mass number of 40.

1. How many protons and neutrons are present in an atom of Argon-40 (Ar, $Z=18$, $A=40$)?
2. How many protons and neutrons are present in an atom of Calcium-40 (Ca, $Z=20$, $A=40$)?
3. What are isobars?
4. Are Argon-40 and Calcium-40 isotopes or isobars? Explain.

Ans :

1. Argon-40: Protons = $Z = 18$. Neutrons = $A - Z = 40 - 18 = 22$.
 2. Calcium-40: Protons = $Z = 20$. Neutrons = $A - Z = 40 - 20 = 20$.
 3. Isobars are atoms of different elements with different atomic numbers but the same mass number.
 4. Argon-40 and Calcium-40 are isobars. They are atoms of different elements (Argon and Calcium, with atomic numbers 18 and 20 respectively) but have the same mass number (40).
- 117.** An atom 'X' has its K and L shells completely filled with electrons.
1. How many electrons are present in the K-shell if it is completely filled?
 2. How many electrons are present in the L-shell if it is completely filled?
 3. What is the total number of electrons in atom 'X'? What is its atomic number?
 4. What can you predict about the chemical activity or valency of atom 'X'? Name an element that fits this description.

Ans :

1. If the K-shell is completely filled, it has 2 electrons.
2. If the L-shell is completely filled, it has 8 electrons.
3. The total number of electrons in atom 'X' is 2 (K-shell) + 8 (L-shell) = 10 electrons. Its atomic number is 10.

4. Since atom 'X' has a completely filled outermost shell (L-shell with 8 electrons, an octet), it will be chemically inert or very unreactive. Its valency will be zero. The element that fits this description is Neon (Ne).

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19. What type of chemical bond is present in a solid compound that does not conduct electricity in the solid state but conducts electricity when dissolved in water?

Ans :

An ionic bond is present in such a compound. In the solid state, the ions are locked in a fixed lattice and cannot move to conduct electricity, but when dissolved in water, the lattice breaks apart and the ions become free-moving, allowing the solution to conduct an electrical current.

20. Metal M, with two electrons in its valence shell (M shell), reacts with oxygen to form a compound that is slightly soluble in water. Predict its:
- formula
 - type of bond
 - electrical conductivity of its aqueous solution.

Ans :

- The formula of the compound is MO .
- The type of bond present is an ionic bond, formed by the transfer of two electrons from the metal to the oxygen atom.
- Its aqueous solution will conduct electricity because the portion of the compound that dissolves will break apart into free-moving M^{2+} and O^{2-} ions capable of carrying a current.

21. Find the molecular mass of nitric acid (HNO_3).
Atomic mass — H = 1 u; N = 14 u; O = 16 u.

Ans :

The molecular mass of nitric acid is calculated as:
1 u (for H) + 14 u (for N) + (3 × 16 u) (for O)
= 1 + 14 + 48 = 63 u.

22. Find the molecular mass of methane (CH_4).
Atomic mass — C = 12 u; H = 1 u.

Ans :

The molecular mass of methane is calculated as:
12 u (for C) + (4 × 1 u) (for H) = 12 + 4 = 16 u.

23. Find the formula unit mass of potassium chloride (KCl).
Atomic mass — K = 39 u; Cl = 35.5 u.

Ans :

The formula unit mass of potassium chloride is calculated as: 39 u (for K) + 35.5 u (for Cl) = 74.5 u.

24. Find the formula unit mass of magnesium hydroxide, $Mg(OH)_2$.
Atomic mass — Mg = 24 u; O = 16 u; H = 1 u.

Ans :

The formula unit mass of magnesium hydroxide is calculated as:
= 24 u (for Mg) + 2 × (16 u + 1 u) (for OH)
= 24 + 2 × (17) = 24 + 34 = 58 u.

NCERT EXERCISE

1. A particular element (A) has one electron in its third shell. There is another element (B) with six electrons in its second shell.
- How many electrons does A tend to give or take to become stable?
 - What kind of ion would it form?
 - How many electrons does B tend to give or take to become stable?
 - What kind of ion would it form?
 - If A and B were to combine, what kind of bond would be formed?
 - What would be the formula for the compound thus formed?

Ans :

- Element A has one electron in its outermost shell (electronic configuration 2, 8, 1). To achieve a stable octet, it will tend to give (lose) 1 electron.
- By losing one negatively charged electron, element A will form a positively charged ion known as a cation with a charge of +1 (A^+).
- Element B has six electrons in its outermost shell (electronic configuration 2, 6). To complete its octet and become stable, it will tend to take (gain) 2 electrons.
- By gaining two negatively charged electrons, element B will form a negatively charged ion known as an anion with a charge of -2 (B^{2-}).
- Since element A transfers an electron and element B gains electrons to achieve stability, they will form an ionic bond (bond by electron transfer).
- The valency of A is 1 and the valency of B is 2. By crossing over their valencies, the formula of the compound formed will be A_2B .

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- Atoms of different elements may be similar in some respect.
- Atom is no longer indestructible, Later, it can be converted into energy.
- Dalton's atomic theory fails to explain how and why different elements combine with each other to give compound atoms.

3.3 Atom

It is the smallest particle of the element that cannot be further divided and still retains all the characteristic properties of that element. It maintains its identity in all physical and chemical changes.

3.4 Atomic Symbol

Is is a character or figure that is used to represent an atom of an element. Alchemists were ancient chemists who used strange symbols to represent elements.

3.5 Chemical Symbol

It is a short-hand notation derived from the scientific name of a chemical element.

- The symbol of an element is the initial letter of its common English, Latin, Greek or German name which is written as capital letter, e.g., hydrogen (H), carbon (C), nitrogen (N), etc.
- In case, the first letter is same for two or more elements, a two-letter system is used as a symbol for such elements. The first letter is written in capital letter while the second letter is written in small letter, for example, carbon (C), calcium (Ca), cadmium (Cd), chlorine (Cl), cobalt (Co), copper (Cu), chromium (Cr), cesium (Cs) and curium (Cm).

Significance of the Chemical Symbol

A particular symbol shows a particular element and represents only one atom of that element. It represents a fixed mass of that element which is same as the atomic mass of the element. The chemical formulae of compounds are written using atomic symbols.

3.6 Atomic Mass

It is the mass of an atom of a chemical element.

1. Atomic Mass Unit

In 1961, IUPAC adopted unified atomic mass unit (u) or Dalton (da) as the unit of atomic mass.

Unified atomic mass unit (u) is equal to 1/12th the mass of a carbon-12 atom.

$$\begin{aligned} 1 \text{ atomic mass unit} &= \frac{\text{Mass of a C - 12 atom}}{12} \\ &= \frac{1.9924 \times 10^{-23} \text{ g}}{12} \\ &= 1.66 \times 10^{-24} \text{ g} \end{aligned}$$

2. Relative Atomic Mass

It is the average mass of atoms of an element as compared to 1/12th the mass of one carbon-12 atom.

$$\begin{aligned} \text{Thus, relative atomic mass of an element (A}_r\text{)} \\ &= \frac{\text{Average mass of 1 atom of element}}{(1/12)\text{th the mass of 1 atom of C - 12 atom}} \end{aligned}$$

Here, the word average is used because most of the elements, as they occur in nature, comprise isotopes and so, all atoms of the elements do not have the same mass.

3. Gram Atomic Mass

It is the atomic mass of an element expressed in grams.

4. MOLECULE

It is the smallest part of an element or a compound which has all the properties of that element or compound and can exist independently.

4.1 Molecules of Elements

Molecules of elements are formed by the combining two or more atoms of the same element, e.g., a molecule of hydrogen (H₂) is formed by combining two atoms of hydrogen.

4.2 Atomicity

It is the number of atoms present in a molecule of the element, e.g., hydrogen (H₂), oxygen (O₂), nitrogen (N₂) and chlorine (Cl₂) exist as diatomic molecules, phosphorus (yellow) forms discrete P₄ molecules and sulphur exists as S₈ molecules.

4.3 Buckminsterfullerene

It is a form of carbon with formula C₆₀. It is also called bucky-ball.

4.4 Molecules of Compounds

The compound consists of more than one type of atoms. In molecules of compounds, atoms of different elements are bonded together by chemical bonds.

CHAPTER 9

Atomic Foundations of Matter

SUMMARY

1. LAW OF CONSERVATION OF MASS

Antoine Lavoisier established the law of conservation of mass. According to this law, there is no loss or gain in mass during a chemical or physical change. In other words, matter can neither be created nor destroyed.

2. LAW OF CONSTANT PROPORTION

This law was given by French chemist Joseph Proust. It states that every pure compound contains the same elements combined in the same proportion by mass. That means, the chemical composition of a compound is definite, so, this law is also termed as law of constant composition or definite proportion.

3. DALTON'S ATOMIC THEORY

John Dalton used two fundamental laws of chemical combination, i.e., the law of conservation of mass and law of constant proportion for his atomic theory.

The assumptions of Dalton's atomic theory are as follows :

1. All forms of matter are composed of very small discrete particles called atoms.
2. An atom cannot be further broken down into still simpler particles.
3. Atoms can neither be created nor be destroyed in the chemical process.
4. Atoms of a particular element are same in all respects, i.e., they have same mass, size and chemical properties.
5. Atoms of one element are different from those of any other element, e.g., atoms of different elements can be distinguished from each other by their respective masses.

6. Atoms of different elements may combine in simple whole number ratio to form compound atoms (molecules) of a new substance.

As per Dalton's atomic theory, atom which is the smallest particle of an element, cannot be further divided and it retains all the characteristic properties of that element.

3.1 Dalton's Atomic Theory and the Law of Conservation of Mass

As per Dalton's atomic theory, matter is made up of atoms which can neither be created nor destroyed. So, the number of different kinds of atoms in products of a chemical reaction must be same as the number of all kinds of atoms in reactants. Thus, the total mass of products of a chemical reaction is always equal to the total mass of reactants.

3.2 Dalton's Atomic Theory and the Law of Constant Proportion

As per Dalton's atomic theory, each element is made up of atoms. The atoms of different elements combine together in whole numbers to give compound atoms of a new substance. Since the number and kind of atoms of each element in a compound are definite, masses of the constituent elements in a compound will be in a definite ratio. The law involved here is the law of constant proportion.

Drawbacks of Dalton's atomic theory are as follows :

1. The assumption that an atom is indivisible that is no longer true. An atom can be decomposed into subatomic particles like electron, proton and neutron.
2. Atoms of the similar element may not be equal in all respects. Atoms of the similar element may have different masses. Such atoms of the same element having different masses are termed as isotopes.

7.1 Mole in Terms of Mass

1 mole of a substance is the quantity of that substance equal to its 'molecular mass' in grams. Here, the molecular mass has a general meaning, i.e., if the entity is atom, it is the atomic mass, if the entity is molecule, it is the molecular mass and so on.

7.2 Molar Mass

It is the mass in grams of one mole of a substance. The unit of molar mass is g mol^{-1} .

7.3 Molar Volume

It is one mole of any gaseous substance at 1 atmospheric pressure and 273 K temperature which occupies a volume of 22.4 litres or 22400 mL.

8. PERCENTAGE COMPOSITION OF A COMPOUND

The composition of a compound is expressed as mass percentage of each element present in that compound.

$$\text{Mass percentage of an element in a compound} = \frac{\text{Mass of the element in a given mass of compound}}{\text{Total mass of that compound}} \times 100$$

Steps used to determine percentage composition from the formula of the compound :

1. Write the correct formula of the compound.
2. Find the molecular mass of the compound.
3. Determine the percentage of each element by using following formula:

$$\text{Mass of the element in one mole of the compound} = \frac{\text{Mass of the element in one mole of the compound}}{\text{Molar mass of the compound}} \times 100$$

Steps used to determine empirical formula :

1. Find the percentage of each element from the given data. We get percentage of oxygen by subtracting the sum of all other percentages from 100. Percentage of O = $\{100 - \text{sum of percentages of all other elements}\}$
2. Calculate the relative number of atoms by dividing the percentage of each element present in the compound by its atomic mass.
3. To determine the simplest ratio of atoms, find out the lowest value of relative number of atoms and divide each value of relative number of atoms by this value. If the simplest ratios calculated are not complete integers, multiply them by a common factor to get integer whole numbers of the simplest ratios.

4. Write symbols of all constituent atoms with their respective number of atoms as subscript to lower right-hand corner of the symbol. Thus, We get empirical formula of the compound.

Determination of molecular formula :

To determine the molecular formula, follow the steps used in finding empirical formula. Determine the empirical mass. If empirical and molecular masses of the compound are same, the empirical and molecular formulae will be same.

$$\text{Molecular formula} = n \times \text{Empirical formula}$$

where, n (integer)

$$= \frac{\text{Molecular mass of compound}}{\text{Empirical mass of compound}}$$

PAUSE AND PONDER

1. A student burns 10 g of ethanol in an open beaker. After the reaction, no residue is left in the beaker. Does this mean the Law of Conservation of Mass is violated? Explain.

Ans :

No, the Law of Conservation of Mass is not violated in this reaction. When ethanol burns, it reacts with oxygen to produce carbon dioxide gas and water vapour, which escape into the atmosphere because the beaker is open. If the reaction were conducted in a closed system and the mass of the escaping gases was measured along with the oxygen consumed, the total mass of the reactants would equal the total mass of the products.

2. When 20 g of hydrogen reacts completely with 160 g of oxygen, how much water is formed according to the Law of Conservation of Mass?

Ans :

According to the Law of Conservation of Mass, the total mass of the product (water) will be equal to the total mass of the reactants, which is 20 g of hydrogen plus 160 g of oxygen. Therefore, 180 g of water is formed.

3. A compound consists of 40% sulfur and 60% oxygen by mass. In a sample of the same compound containing 20 g of sulfur, what mass of oxygen must be present to satisfy the Law of Constant Proportions?

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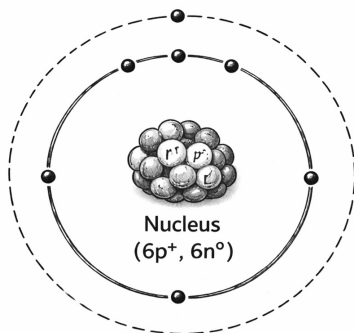
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octet), then the atom will be stable and less reactive.

- 113.** A particular atom of carbon (C) has 6 protons and 6 neutrons in its nucleus. It also has 6 electrons revolving around the nucleus.



1. What is the atomic number (Z) of this carbon atom? What does it represent?
2. What is the mass number (A) of this carbon atom? How is it calculated?
3. How would you represent this carbon atom using the standard notation (Symbol with A and Z)?
4. If this carbon atom loses one electron, what will be the charge on the resulting ion? Will its atomic number or mass number change?

Ans :

1. The atomic number (Z) of this carbon atom is 6. It represents the number of protons in the nucleus.
2. The mass number (A) of this carbon atom is 12. It is calculated as the sum of the number of protons and neutrons ($A = 6 \text{ protons} + 6 \text{ neutrons} = 12$).
3. The carbon atom would be represented as ${}^{12}_6\text{C}$
4. If the carbon atom loses one electron, it will have 6 protons and 5 electrons, resulting in a net charge of $+1$. The resulting ion will be C^+ . Its atomic number (6) and mass number (12) will not change, as these are determined by the number of protons and neutrons in the nucleus.

- 114.** A sodium atom (Na) has an atomic number (Z) of 11. According to the Bohr-Bury scheme, electrons fill different energy shells (K, L, M, N...) in a specific order, with each shell having a maximum capacity for electrons.

1. How many protons and how many electrons are there in a neutral sodium atom?

2. What is the maximum number of electrons that can be accommodated in the K-shell, L-shell, and M-shell respectively?
3. Write the distribution of electrons in a sodium atom into its K, L, and M shells.
4. How many valence electrons does a sodium atom have?

Ans :

1. In a neutral sodium atom, there are 11 protons (since $Z=11$) and 11 electrons.
2. K-shell can accommodate a maximum of $2n^2 = 2(1)^2 = 2$ electrons.
L-shell can accommodate a maximum of $2n^2 = 2(2)^2 = 8$ electrons.
M-shell can accommodate a maximum of $2n^2 = 2(3)^2 = 18$ electrons (though for elements up to $Z=18$, the outermost shell does not accommodate more than 8).
3. The distribution of electrons in a sodium atom (11 electrons) is:
4. A sodium atom has 1 valence electron (the electron in the outermost M-shell).

- 115.** Hydrogen is known to exist in three isotopic forms: Protium, Deuterium, and Tritium. Protium has 1 proton and 0 neutrons. Deuterium has 1 proton and 1 neutron. Tritium has 1 proton and 2 neutrons.

1. What are isotopes?
2. What is the atomic number of Protium, Deuterium, and Tritium?
3. What is the mass number of Protium, Deuterium, and Tritium?
4. Do isotopes of an element have similar or different chemical properties? Why?

Ans :

1. Isotopes are atoms of the same element, having the same atomic number but different mass numbers (due to a different number of neutrons).
2. The atomic number of Protium is 1, Deuterium is 1, and Tritium is 1 (since they all have 1 proton).
3. The mass number of Protium is 1 ($1p + 0n$).
The mass number of Deuterium is 2 ($1p + 1n$).
The mass number of Tritium is 3 ($1p + 2n$).
4. Isotopes of an element have similar chemical properties. This is because chemical properties are primarily determined by the number of

representing single bonds. Add two lone pairs of electrons to the central sulfur atom.

- (iii) For Ammonia, draw a central nitrogen atom sharing one electron pair with each of three separate hydrogen atoms to form three single bonds. Add one lone pair of electrons to the central nitrogen atom to complete its octet.

11. Neon (atomic number 10) neither transfers nor shares its valence electrons. Explain.

Ans :

Neon has an electronic configuration of 2, 8, which means its outermost shell is already completely filled with eight electrons. Because it already possesses a stable octet configuration, it does not need to gain, lose, or share any electrons, making it chemically unreactive and inert.

12. What kind of ion will oxygen (O) form?

Ans :

Oxygen has an electronic configuration of 2, 6 and requires two more electrons to complete its octet. Therefore, it will gain two electrons to form a negatively charged anion with a valency of 2- (O_2^-).

13. Fill in the blanks.

Among magnesium and chlorine, magnesium atom can give two electrons to become Mg^{2+} . However, chlorine can take only one electron to become _____. Now, _____ ion of magnesium and _____ ions of chlorine combine to give magnesium chloride.

Ans :

Among magnesium and chlorine, magnesium atom can give two electrons to become Mg^{2+} . However, chlorine can take only one electron to become a chloride ion (Cl^-). Now, one ion of magnesium and two ions of chlorine combine to give magnesium chloride.

14. Show the formation of cations of potassium (K) and calcium (Ca) atoms, and the formation of their corresponding chlorides using diagrams.

Ans :

For potassium chloride formation, depict a potassium atom losing its single valence electron to become a K^+ cation, and a chlorine atom gaining that electron to become a Cl^- anion. The strong electrostatic attraction between the single

K^+ and Cl^- ions forms KCl. For calcium chloride formation, depict a calcium atom losing its two valence electrons to form a Ca^{2+} cation, and two separate chlorine atoms each accepting one of those electrons to form two Cl^- anions. The electrostatic attraction between one Ca^{2+} ion and two Cl^- ions forms $CaCl_2$.

15. Illustrate how sodium sulfide (Na_2S) is formed.

Ans :

Sulfur has an electronic configuration of 2, 8, 6 and needs two electrons to achieve a stable octet, while sodium has a configuration of 2, 8, 1 and needs to lose one electron. Two sodium atoms each donate their single valence electron to one sulfur atom. This electron transfer results in two positively charged sodium cations (Na^+) and one negatively charged sulfide anion (S^{2-}), which are then held together by electrostatic forces to form sodium sulfide.

16. Name the following:

- (i) CO_2
- (ii) NO_2
- (iii) SF_6
- (iv) PCl_3

Ans :

- (i) Carbon dioxide
- (ii) Nitrogen dioxide
- (iii) Sulfur hexafluoride
- (iv) Phosphorus trichloride

17. Write the formula for the following:

- (i) Sodium hydrogencarbonate
- (ii) Sulfur dioxide
- (iii) Ferric chloride
- (iv) Cuprous oxide

Ans :

- (i) $NaHCO_3$
- (ii) SO_2
- (iii) $FeCl_3$
- (iv) Cu_2O

18. Write the formulae for the compounds formed from the following pairs of ions:

- (i) Fe^{3+} and OH^-
- (ii) K^+ and CO_3^{2-}

Ans :

- (i) $Fe(OH)_3$
- (ii) K_2CO_3

Ans :

The mass ratio of sulfur to oxygen in the compound is 40:60, which simplifies to 2:3. To maintain this constant proportion, if the sample has 20 g of sulfur, it must contain 30 g of oxygen.

4. Carbon monoxide (CO) contains carbon and oxygen in the mass ratio of 3:4. How much oxygen will combine with 9 g of carbon to form carbon monoxide?

Ans :

Since the mass ratio of carbon to oxygen is 3:4, every 3 g of carbon requires 4 g of oxygen. Therefore, 9 g of carbon will combine with 12 g of oxygen to form carbon monoxide.

5. The Law of Definite Proportions holds true for compounds but not for mixtures. Give reason.

Ans :

Compounds are formed by chemical reactions where specific elements combine in fixed, unchangeable mass ratios to create a new substance with unique properties. Mixtures, on the other hand, are formed by physically blending substances together, and their components can be mixed in any variable proportion without altering their individual chemical identities.

6. Students X and Y, both prepared an oxide of copper by combining copper and oxygen in the ratios of 4:1 and 8:2, respectively. Do their results justify the Law of Constant Proportions? Explain.

Ans :

Yes, their results justify the Law of Constant Proportions. The ratio of 8:2 obtained by Student Y simplifies to 4:1, which is exactly the same ratio obtained by Student X. This proves that regardless of how the copper oxide was prepared or in what quantities, the elements copper and oxygen always combined in the same fixed mass ratio.

7. **Assertion (A):** 2 g of hydrogen combines with 16 g of oxygen to form 18 g of water.

Reason (R): According to Dalton's Atomic Theory, atoms combine in a simple whole number ratio by mass to form compounds.

Choose the correct option:

- (i) Both A and R are true, and R is the correct explanation of A.
(ii) Both A and R are true, but R is not the correct explanation of A.

(iii) A is true, but R is false.

(iv) A is false, but R is true.

Ans :

(iii) A is true, but R is false. The assertion is factually correct as it follows the Law of Conservation of Mass and the fixed combining mass ratio of water. However, the reason is false because Dalton's theory states that atoms combine in simple whole number ratios by number, not by mass, to form compounds.

8. Nitrogen has five valence electrons. Draw the structure of the nitrogen molecule (N_2).

Ans :

To depict the structure, draw two overlapping circles representing two nitrogen atoms. In the overlapping region, place three pairs of dots to represent the three pairs of shared electrons forming a triple covalent bond. In the non-overlapping region of each circle, place one pair of dots to represent the remaining lone pair of electrons on each nitrogen atom.

9. The atomic number of fluorine is 9. Explain the formation of the fluorine molecule (F_2).

Ans :

With an atomic number of 9, a fluorine atom has an electronic configuration of 2, 7, meaning it requires one more electron to complete its outermost octet. To achieve this stable configuration, two fluorine atoms come together and share one pair of electrons. This mutual sharing forms a single covalent bond, holding the two atoms together as a stable fluorine molecule.

10. Show the formation of the following molecules:

- (i) Carbon dioxide (CO_2)
(ii) Hydrogen sulfide (H_2S)
(iii) Ammonia (NH_3)

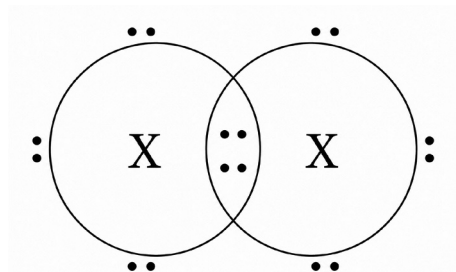
Ans :

- (i) For Carbon dioxide, draw a central carbon atom sharing two electron pairs with an oxygen atom on its left, and another two electron pairs with an oxygen atom on its right, representing double bonds. Add two lone pairs of electrons to each oxygen atom.
(ii) For Hydrogen sulfide, draw a central sulfur atom sharing one pair of electrons with a hydrogen atom on its left and another pair with a hydrogen atom on its right,

2. An element X has six electrons in its outer shell and forms a diatomic molecule.
- Why would that be so?
 - What kind of bond would it form?
 - Draw the structure of the molecule it would form.
 - A certain other element Y has two electrons in its second shell. Draw the structure of the molecule that X would form with Y.

Ans :

- Element X has 6 valence electrons and needs 2 more to complete its stable octet configuration. By sharing two pairs of electrons with another atom of X, both atoms can achieve stability, resulting in the formation of a diatomic molecule (X_2).
- Since it involves the sharing of electrons between atoms of the same element, it forms a covalent bond. Specifically, it forms a double covalent bond because two pairs of electrons are shared.
-



- Element Y has 2 valence electrons and will transfer them to element X (which needs 2 electrons) to form an ionic compound. To draw this, write the symbol Y with two dots next to it, and symbol X with six dots around it. Draw arrows from the two dots of Y pointing towards X to indicate electron transfer. Then, draw the resulting structure: a Y^{2+} ion (with no dots) positioned next to an X^{2-} ion enclosed in square brackets $[X]^{2-}$ with 8 dots inside the brackets to show its completed octet.
3. You want to design a new ionic compound, where the total positive charge is $6+$ and the total negative charge is $6-$. Which of the following combinations gives the correct number of ions?
- 2 Al^{3+} and 3 Cl^-
 - 3 Mg^{2+} and 1 PO_4^{3-}
 - 2 Fe^{3+} and 3 O^{2-}

- 3 Ca^{2+} and 2 SO_4^{2-}

Ans :

(iii) 2 Fe^{3+} and 3 O^{2-} is the correct option. The total positive charge from 2 iron ions is $2 \times (+3) = +6$, and the total negative charge from 3 oxide ions is $3 \times (-2) = -6$. This precisely matches the required $6+$ and $6-$ charges to form a neutral compound (Fe_2O_3).

4. Choose the correct statement(s) and correct the false statement(s).
- Elements are made up of molecules and compounds are made up of atoms.
 - The molecule of a compound is always made up of two or more atoms of the same kind.
 - One molecule of nitrogen gas contains three nitrogen atoms.
 - Water is made of two hydrogen atoms, covalently bonded with one oxygen atom.

Ans :

- This statement is false. Corrected statement: Elements are made up of atoms of the same kind, while compounds are made up of molecules or ions containing two or more different types of atoms combined in a fixed ratio.
- This statement is false. Corrected statement: The molecule of a compound is always made up of two or more atoms of different elements chemically bonded together.
- This statement is false. Corrected statement: One molecule of nitrogen gas (N_2) is diatomic and contains exactly two nitrogen atoms.
- This statement is true. A water molecule (H_2O) is formed by the sharing of electrons between one oxygen atom and two hydrogen atoms.

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5. Write the chemical formulae for the following compounds.
- Aluminium nitrate
 - Calcium oxide
 - Ferric oxide

Ans :

- $Al(NO_3)_3$
- CaO
- Fe_2O_3

OBJECTIVE QUESTIONS

1. In an activity demonstrating a physical change, salt is fully dissolved in water. What is practically observed regarding the mass of the resulting solution?
- (A) The mass of the solution is noticeably less than the sum of initial masses due to dissolution.
 (B) The mass of the solution is exactly equal to the sum of the masses of water and salt taken.
 (C) The mass of the solution slightly increases as the salt particles absorb kinetic energy from water.
 (D) The mass fluctuates constantly depending on the temperature of the surrounding environment.

Ans : (B)

During the physical change of dissolving salt in water, the total mass of the resulting solution exactly equals the sum of the initial masses of the water and the salt. This observation practically demonstrates that mass remains completely unchanged when substances undergo physical changes like dissolution at normal room temperatures.

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2. When baking soda is experimentally added to vinegar in an open conical flask, why does the final reading on the digital weighing balance differ from the initial reading?
- (A) The vinegar absorbs moisture from the air, increasing the overall mass.
 (B) The baking soda decomposes to form a heavy precipitate that affects the balance mechanism.
 (C) Carbon dioxide gas produced during the chemical reaction escapes into the surrounding atmosphere.
 (D) The reaction is highly endothermic, which causes a temporary physical malfunction in the balance.

Ans : (C)

When baking soda and vinegar react in an open conical flask, they produce carbon dioxide gas along with other substances. Because the flask is left open, the newly formed gas quickly escapes into the surrounding atmosphere. This escaping gas carries mass away, resulting in a lower final reading on the weighing balance.

3. Carefully match the specific general class of typical chemical compounds correctly detailed in List-I precisely with their most highly characteristic internal physical structural properties strictly described in List-II.

	List-I		List-II
P.	Typical Ionic Compounds	1.	Features highly intense internal electrostatic bonds, yielding high melting points and high aqueous solubility
Q.	Typical Covalent Compounds	2.	Features substantially weaker intermolecular forces, strictly yielding low boiling points and primary solubility only in non-polar organic petrol.

- (A) P-2, Q-1
 (B) P-1, Q-2
 (C) P-1, Q-1
 (D) P-2, Q-2

Ans : (B)

Ionic substances normally feature exceptionally high melting temperatures due to intense internal electrostatic bonding. They usually dissolve rapidly in water, generating highly conductive solutions. In sharp contrast, standard covalent molecules primarily display notably low boiling points because of weaker intermolecular forces. Additionally, they dissolve almost exclusively in non-polar organic solvents.

4. Arrange the following steps in the correct chronological order to experimentally verify the Law of Conservation of Mass using baking soda and vinegar in a closed system:
1. Fix the balloon securely to the mouth of the conical flask without allowing the contents to mix.
 2. Pour vinegar into the conical flask and put baking soda into the balloon.
 3. Weigh the conical flask containing vinegar and the attached balloon containing baking soda together.
 4. Lift the balloon upwards, allowing baking soda to fall directly into the vinegar.
 5. Record the final reading after the brisk effervescence completely stops.
- (A) 2, 1, 3, 4, 5
 (B) 1, 2, 4, 3, 5

Total mass of reactants

= mass of sodium carbonate + mass of acetic acid
= 5.3 g + 6.0 g = 11.3 g.

Total mass of products

= mass of carbon dioxide + mass of water
+ mass of sodium acetate
= 2.2 g + 0.9 g + 8.2 g = 11.3 g.

Since the total mass of reactants (11.3 g) is exactly equal to the total mass of products (11.3 g), the law of conservation of mass is verified as valid for this reaction.

12. If a species has 11 protons, 12 neutrons and 10 electrons then

- what is its atomic number and mass number?
- is it neutral, a cation or an anion? Explain.
- write its electronic configuration.
- name the species.

Ans :

- The atomic number is the number of protons, which is 11. The mass number is the sum of protons and neutrons, which is $11 + 12 = 23$.
- It is a cation. A neutral atom would have an equal number of protons and electrons (11 of each). Since this species has 11 positively charged protons but only 10 negatively charged electrons, it has a net positive charge of +1, making it a cation.
- Since it has 10 electrons, its electronic configuration is 2, 8.
- The atomic number 11 corresponds to the element Sodium. Because it has a +1 charge, the species is a sodium ion (Na^+).

13. Two elements, A and B, have the following configurations—

A: 2, 8, 5

B: 2, 8, 7

- Which element is more reactive?
- Will A and B form ionic or covalent bonds when they combine? Explain using electron transfer or sharing.
- Predict the formula of the compound they would form.

Ans :

- Element B is more reactive. It has 7 valence electrons and only needs to gain or share one single electron to achieve a stable octet, which requires less energy and occurs much more readily than element A's need to gain or share three electrons.

- Elements A and B will form covalent bonds when they combine. Both are non-metals that are short of electrons to complete their stable octets. Therefore, neither will transfer its electrons entirely; instead, they will share their valence electrons to achieve mutually stable electronic configurations.
- Element A needs 3 electrons (valency of 3), and element B needs 1 electron (valency of 1). By criss-crossing their valencies, the predicted formula for the resulting compound is AB_3 .

14. **Assertion (A):** Copper sulfate conducts electricity in the molten state but not in the solid state.

Reason (R): Copper and sulfate ions are fixed in the lattice in molten state, while in solid state they can move freely.

Choose the correct option:

- Both A and R are true, and R is the correct explanation of A.
- Both A and R are true, but R is not the correct explanation of A.
- A is true, but R is false.
- A is false, but R is true.

Ans :

(iii) A is true, but R is false. The assertion is correct because ionic compounds like copper sulfate conduct electricity only when their ions are free to move. The reason is completely false because the states are reversed; ions are fixed in a crystal lattice in the solid state and become free to move only when the compound is in the molten or aqueous state.

15. The species ^{27}Al , $^{30}\text{Br}^-$ and $^{201}\text{Hg}^{2+}$ have 13, 35 and 80 protons, respectively. How many electrons and neutrons do they have?

Ans :

For ^{27}Al (Neutral Aluminium atom): It has 13 protons. Since it is neutral, it has 13 electrons. The number of neutrons is Mass Number - Protons = $27 - 13 = 14$ neutrons.

For $^{30}\text{Br}^-$ (Bromide anion): It has 35 protons. The -1 charge means it has gained one electron, so it has $35 + 1 = 36$ electrons. The number of neutrons is Mass Number - Protons = $80 - 35 = 45$ neutrons.

For $^{201}\text{Hg}^{2+}$ (Mercury cation): It has 80 protons. The +2 charge indicates it has lost two electrons, so it has $80 - 2 = 78$ electrons. The number of neutrons is Mass Number - Protons = $201 - 80 = 121$ neutrons.

in water, these electrostatic forces are overcome, and the ions become free to move. This movement of charged ions facilitates the passage of electric current, lighting the bulb.

25. The table lists the valencies of four hypothetical ions. A student uses the criss-cross method to write the chemical formulae for compounds formed by combining these specific ions. Which of the following chemical formulae is written correctly?

Ion Symbol	Type of Ion	Valency
X	Cation	3
Y	Cation	1
Z	Polyatomic Anion	2
W	Monoatomic Anion	1

- (A) XZ_2
 (B) Y_2Z
 (C) XW_2
 (D) YW_2

Ans : (B)

When determining chemical formulae, the valencies of combining ions are crossed over to become subscripts. Cation Y has a valency of one, and polyatomic anion Z has a valency of two. Crossing these gives two Y ions for every one Z ion, making the correct chemical formula Y_2Z . The other options apply the valencies incorrectly.

26. According to the foundational principles of Dalton's Atomic Theory, which of the following statements represents an absolutely incorrect assumption regarding the nature of atoms?
- (A) Atoms are the incredibly tiny, fundamental participating particles in all chemical reactions.
 (B) The relative number and kinds of atoms naturally remain totally constant in a given compound.
 (C) Atoms of completely different elements can naturally possess the exact same physical mass and identical chemical properties.
 (D) Atoms simply rearrange themselves during chemical changes without being destroyed.

Ans : (C)

A major cornerstone of Dalton's original atomic theory strictly states that atoms belonging to different chemical elements inherently possess completely different masses and varying chemical properties. Therefore, the incorrect assumption is that atoms of entirely distinct elements could

somehow share the exact same physical mass and display identical chemical behaviour.

27. When a small piece of magnesium ribbon violently burns in the surrounding air, it formally produces a bright white powder of magnesium oxide. According to Dalton's classical atomic theory, exactly what happens to the reacting atoms during this violent process?
- (A) The solid magnesium atoms are permanently destroyed, and completely new magnesium oxide molecules are freshly created.
 (B) The atoms of magnesium and oxygen merely undergo a profound structural rearrangement to successfully form the stable compound.
 (C) The individual oxygen atoms undergo rapid spontaneous division to physically bond with the heavier magnesium atoms.
 (D) The constituent elemental atoms magically lose all their internal mass to spontaneously release brilliant white heat and light.

Ans : (B)

When magnesium metal rigorously burns in the air, the fundamental atoms themselves are absolutely not destroyed or miraculously changed into entirely different elements. According to John Dalton's reliable atomic theory, the individual atoms of magnesium and oxygen merely undergo a profound structural rearrangement to successfully form the stable compound magnesium oxide.

- In scientific terminology, which of the following statements represents the most accurate and comprehensive definition of a chemical molecule?
- (A) A highly charged, totally unstable individual atomic particle that inherently cannot exist independently.
 (B) An electrically neutral chemical entity consisting of more than one atom that can completely exist independently and shows all properties of that substance.
 (C) A gigantic, infinitely repeating rigid three-dimensional crystal lattice composed solely of oppositely charged ions.
 (D) A highly unstable physical mixture of completely different unbonded elements occurring randomly at room temperature.

Ans : (B)

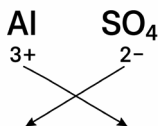
A molecule is scientifically defined as an electrically neutral chemical entity constructed from more than one atom. It possesses the unique capacity for complete independent existence while simultaneously displaying all the fundamental

- (C) 3, 2, 1, 4, 5
(D) 2, 3, 1, 5, 4

Ans : (A)

To verify the Law of Conservation of Mass in a closed system, reactants are first kept separate inside a sealed apparatus. The initial combined mass is measured. Then, they are intentionally mixed by lifting the balloon, initiating the chemical reaction. Finally, the total mass of the sealed system is measured again.

5. The conceptual diagram illustrates the criss-cross method used to determine the chemical formula of an ionic compound formed by combining aluminium and sulfate ions. Following this method, what is the correct final chemical formula for aluminium sulfate?



- (A) Al_2SO_4
(B) $\text{Al}(\text{SO}_4)_3$
(C) $\text{Al}_3(\text{SO}_4)_2$
(D) $\text{Al}_2(\text{SO}_4)_3$

Ans : (D)

To write the correct chemical formula, the numerical values of the respective ionic charges are criss-crossed to become the subscripts of the opposing ions. Aluminium has a valency of three, and the sulfate polyatomic ion has a valency of two. Criss-crossing these exactly yields two aluminium ions for every three sulfate ions.

6. Who is officially recognised as the Father of Modern Chemistry for proposing the fundamental Law of Conservation of Mass in the year 1789?
- (A) John Dalton
(B) Joseph Louis Proust
(C) Antoine Lavoisier
(D) J.J. Thomson

Ans : (C)

The Law of Conservation of Mass, which states that mass can neither be created nor destroyed in a chemical reaction, was proposed by the French chemist Antoine Lavoisier in the year seventeen eighty-nine. He is widely recognised as the Father of Modern Chemistry due to his highly careful and rigorous experimental work.

7. **Assertion (A):** When sodium sulfate reacts with barium chloride in an open conical flask, there is absolutely no change in the total mass.

Reason (R): The chemical reaction produces a solid white precipitate of barium sulfate without evolving any gaseous products.

- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

When aqueous solutions of sodium sulfate and barium chloride are mixed together, they react to form solid barium sulfate and aqueous sodium chloride. Because this specific chemical reaction does not produce any gaseous products that could escape into the atmosphere, the total mass remains perfectly conserved even in an open experimental system.

8. In a closed chemical reaction, 5.3 g of sodium carbonate reacts completely with 6.0 g of acetic acid. The final products are 2.2 g of carbon dioxide, 0.9 g of water, and an unknown mass of sodium acetate. Based on the Law of Conservation of Mass, what is the exact mass of the sodium acetate formed?

- (A) 8.0 g
(B) 8.2 g
(C) 10.4 g
(D) 11.3 g

Ans : (B)

According to the Law of Conservation of Mass, the total mass of the reactants must equal the total mass of the products. The mass of reactants is five point three plus six point zero, which equals eleven point three grams. Subtracting the known product masses gives exactly eight point two grams of sodium acetate.

9. Consider the following statements regarding the experimental verification of the Law of Conservation of Mass using barium chloride and sodium sulfate:
- Both conical flasks should be kept on the digital weighing balance to successfully prevent errors caused by a small amount of solution stuck to the walls during transfer.
 - The specific reaction between sodium sulfate and barium chloride can be accurately carried out in an open system.

17. **Assertion (A):** The Law of Definite Proportions fundamentally applies to standard chemical compounds but absolutely not to simple physical mixtures.

Reason (R): In a physical mixture, the constituent elementary substances can be easily combined together in any variable proportion by mass.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

A true chemical compound inherently consists of specific elements that are tightly bonded together in an unchangeable, fixed mass ratio. Conversely, a physical mixture simply blends different substances without forming chemical bonds. Therefore, these physical mixtures can easily have highly variable compositions, meaning they totally ignore the strict Law of Definite Proportions.

18. **Assertion (A):** The universally established Law of Conservation of Mass is theoretically and logically explained by Dalton's Atomic Theory.

Reason (R): Dalton clearly postulated that during a chemical reaction, atoms are absolutely indivisible microscopic particles that can neither be physically created nor destroyed.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

Antoine Lavoisier experimentally established that mass remains totally conserved during chemical reactions. Later, John Dalton provided a brilliant theoretical explanation for this phenomenon. He boldly postulated that atoms are absolutely indivisible entities that solely rearrange themselves during chemical changes, meaning no new atoms are created and no existing ones are ever destroyed.

19. Pure carbon monoxide gas strictly contains carbon and oxygen combined together in the specific mass ratio of 3:4. If 9 g of solid carbon is completely converted into carbon monoxide,

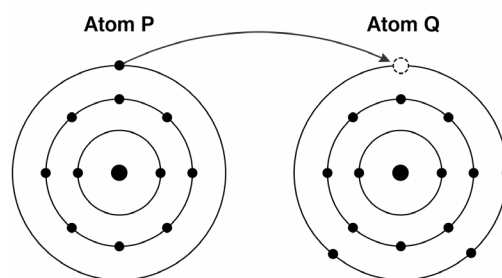
exactly how much oxygen gas is required to react with it?

- (A) 9 g
 (B) 12 g
 (C) 16 g
 (D) 27 g

Ans : (B)

In carbon monoxide, the established mass ratio of carbon to oxygen is exactly three to four. This essentially means that three grams of carbon fundamentally requires four grams of oxygen to react completely. Therefore, to react with nine grams of carbon, one must provide exactly twelve grams of oxygen gas to maintain this ratio.

20. What will be the respective charges on the ions formed from Atom P and Atom Q after the indicated electron transfer is complete?



- (A) P will become P^+ and Q will become Q^- .
 (B) P will become P^- and Q will become Q^+ .
 (C) P will become P^{2+} and Q will become Q^{2-} .
 (D) Both atoms will remain electrically neutral by sharing the electron.

Ans : (A)

Atom P has one valence electron and loses it to achieve a stable octet, thereby losing one negative charge to become a positively charged cation (P^+). Atom Q has seven valence electrons and gains this single electron to complete its octet, acquiring an extra negative charge to become an anion (Q^-).

21. In many ancient human civilisations, a highly distinctive red pigment extracted from rocks was historically known as hinga. What is the precise modern chemical composition of this specific mineral substance?

- (A) Copper and carbonate
 (B) Iron and oxygen
 (C) Mercury and sulfur
 (D) Lead and oxide

- (D) No, because the Law of Conservation of Mass strictly applies only to physical changes, not to rapid chemical combustions.

Ans : (C)

The burning of ethanol in an open beaker converts the liquid into completely gaseous products like carbon dioxide and water vapour. Because these newly formed gases freely escape into the surrounding air, the final mass in the beaker appears as zero. This phenomenon perfectly obeys the fundamental Law of Conservation of Mass.

13. A researcher collected four samples labeled as 'Compound X' from different geographic sources and analyzed the masses of its constituent elements, A and B. Which sample is most likely a completely different compound or an impure mixture?

Sample of Compound X	Mass of Element A (g)	Mass of Element B (g)
Sample 1	3.0	4.0
Sample 2	9.0	12.0
Sample 3	4.5	6.0
Sample 4	6.0	9.0

- (A) Sample 1
(B) Sample 2
(C) Sample 3
(D) Sample 4

Ans : (D)

The Law of Constant Proportions states that a pure compound always contains its elements in a fixed mass ratio. Samples 1, 2, and 3 all exhibit a constant mass ratio of three to four for elements A and B. Sample 4 has a ratio of two to three, indicating it is a different substance altogether.

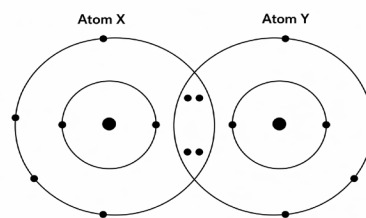
14. Which fundamental chemical law clearly states that in a chemical compound, the constituent elements are always present in definite proportions by mass irrespective of the source?
- (A) Law of Conservation of Mass
(B) Law of Constant Proportions
(C) Law of Multiple Proportions
(D) Law of Gaseous Volumes

Ans : (B)

The Law of Constant Proportions, also known as the Law of Definite Proportions, clearly dictates that chemical compounds always contain exactly

the same elements combined in a strictly fixed ratio by mass. This fundamental principle remains completely true irrespective of the method of preparation or the specific geographical source of the compound.

15. Identify the type of bond formed between Atom X and Atom Y and the total number of electrons shared in this specific interaction.



- (A) Single covalent bond, sharing 2 electrons.
(B) Double covalent bond, sharing 4 electrons.
(C) Ionic bond, transferring 4 electrons.
(D) Triple covalent bond, sharing 6 electrons.

Ans : (B)

The overlapping of valence shells indicates a covalent bond, which involves the sharing of valence electrons. The diagram explicitly shows four electrons grouped as two pairs in the shared central region between Atom X and Atom Y. Sharing two pairs of electrons results in a double covalent bond, eliminating other bond types.

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16. Which of the following options correctly pairs the pure chemical compound with the naturally fixed ratio by mass of its constituent elements?
- (A) Water (Hydrogen : Oxygen) – 8:1
(B) Water (Hydrogen : Oxygen) – 1:8
(C) Carbon dioxide (Carbon : Oxygen) – 1:2
(D) Ammonia (Nitrogen : Hydrogen) – 1:3

Ans : (B)

According to the Law of Constant Proportions, pure water fundamentally consists of hydrogen and oxygen combined in a strict one to eight mass ratio. If nine grams of water undergoes complete decomposition, it will reliably yield exactly one gram of hydrogen gas alongside eight grams of oxygen gas, confirming this universal chemical rule.

3. The chemical reaction produces a totally clear solution with no visible precipitate formed at all.

Select the correct combination:

- (A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 1, 2, and 3

Ans : (A)

When verifying the conservation of mass, keeping all containers on the balance effectively prevents errors from minor liquid transfers. The reaction between barium chloride and sodium sulfate does not generate gas, allowing it to proceed in an open system. However, it specifically forms a highly visible white precipitate of barium sulfate.

10. A student performed three different chemical reactions and recorded the mass before and after the reaction in the table below. Based on the provided data, which of the following conclusions is scientifically correct?

Experiment Setup	Setup P	Setup Q	Setup R
Reactants	Baking soda + Vinegar	Baking soda + Vinegar	Sodium sulfate + Barium chloride
Type of Flask	Open conical flask	Closed flask with balloon	Open conical flask
Initial Mass (g)	150.0	155.0	160.0
Final Mass (g)	148.5	155.0	160.0

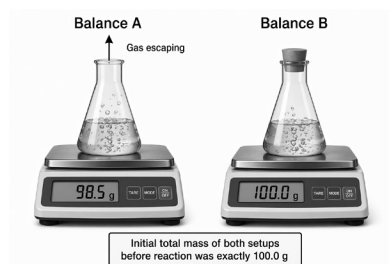
- (A) Setup P violates the Law of Conservation of Mass because the final mass decreased.
(B) Setup Q proves that matter is created when a gas inflates a closed balloon.
(C) Setup R shows mass is conserved because no gaseous product escaped into the surroundings.
(D) The Law of Conservation of Mass only applies to closed systems like Setup Q.

Ans : (C)

In Setup P, the mass decreases because carbon dioxide gas escapes from the open flask. Setup Q demonstrates conservation in a closed system where gas is trapped. Setup R involves a

precipitation reaction with no gaseous products, so mass is conserved even in an open flask, confirming the law without violation.

11. Based on the provided experimental setups, why does the balance on the left show a lower reading than the balance on the right despite starting with identical initial masses?



- (A) Mass is naturally destroyed in open systems during a chemical reaction.
(B) The gas produced in the open flask escapes, carrying mass away, while the closed flask retains it.
(C) The cork on the closed flask reacts chemically with the trapped gas to increase the total mass.
(D) Chemical reactions in open systems do not obey the Law of Conservation of Mass.

Ans : (B)

The Law of Conservation of Mass states mass is neither created nor destroyed. In Setup A, the escaping gas carries mass away into the surroundings, reducing the measured balance reading. Setup B is a closed system; the gas remains trapped inside, ensuring the total mass remains strictly constant at 100.0 g.

12. A student completely burns 10 g of liquid ethanol in an open glass beaker. After the rigorous reaction is completely over, absolutely no visible residue is left in the beaker. Does this specific experimental observation violate the fundamental Law of Conservation of Mass?
- (A) Yes, because the total initial mass of the solid beaker and liquid ethanol has permanently decreased to zero.
(B) Yes, because a chemical reaction must always leave some observable solid residue behind to prove mass conservation.
(C) No, because the products of combustion are entirely gaseous and escape into the atmosphere, making the mass appear to decrease.

Ans : (C)

Ancient civilisations widely used a distinctive red pigment extracted from rocks, historically termed hingula. Over the centuries, scientific analysis clearly revealed that strongly heating this specific mineral, commonly called cinnabar, consistently yielded exactly two elementary substances: mercury and sulfur. These elements always appeared in strict, unvarying mass percentages, directly supporting early chemical laws.

22. A student investigated the physical properties of four unknown solid substances and recorded the observations in the table. Based on these properties, which substance is most likely held together by ionic bonds?

Substance	Solubility in Water	Solubility in Kerosene	Electrical Conductivity (Solid State)	Electrical Conductivity (Aqueous Solution)
Substance K	Soluble	Insoluble	Does not conduct	Conducts
Substance L	Insoluble	Soluble	Does not conduct	Does not conduct
Substance M	Soluble	Insoluble	Does not conduct	Does not conduct
Substance N	Insoluble	Insoluble	Conducts	Conducts

- (A) Substance K
(B) Substance L
(C) Substance M
(D) Substance N

Ans : (A)

Ionic compounds are typically soluble in water, insoluble in organic solvents like kerosene, and conduct electricity in aqueous solutions due to free-moving ions. They do not conduct in the solid state. Substance K matches all these characteristic properties perfectly. Substance L and M exhibit typical covalent traits, while N behaves entirely like a metal.

23. Which of the following specific statements are considered fundamentally correct postulates of Dalton's original Atomic Theory?
1. All matter is made up of very tiny, completely indivisible particles called atoms.
 2. Atoms are inherently divisible into smaller subatomic particles like protons, neutrons, and electrons.
 3. Atoms of a given chemical element are totally identical in mass and chemical properties.

4. Atoms fundamentally combine together in the ratio of simple whole numbers to form compounds.

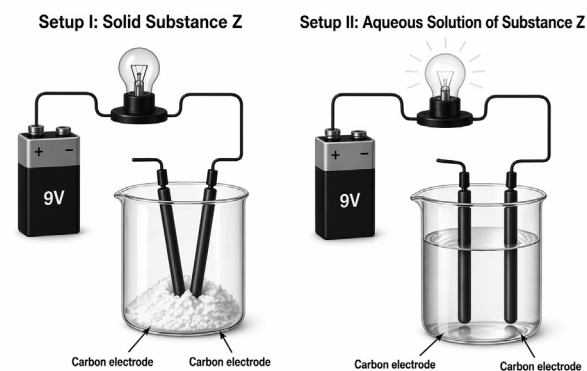
Select the correct option:

- (A) 1, 2, and 3
(B) 1, 3, and 4
(C) 2, 3, and 4
(D) 1, 2, and 4

Ans : (B)

John Dalton fundamentally proposed that matter consists of indivisible, tiny particles called atoms. He notably stated that elements possess identical atoms, whereas different elements have distinctly different atoms. These indivisible atoms combine in simple whole-number ratios. His original theory did not include any knowledge about subatomic particles like protons, neutrons, or electrons.

24. Based on the electrical conductivity test shown for Substance Z in two different states, which statement best categorizes Substance Z and explains the observation?



- (A) Substance Z is a covalent compound; it conducts electricity in water by forming covalent bonds with water molecules.
(B) Substance Z is an ionic compound; it conducts electricity in water because its ions become free to move.
(C) Substance Z is a covalent compound; the bulb lights up because water itself is a strong conductor of electricity.
(D) Substance Z is an ionic compound; it fails to conduct in solid state because its electrons are shared.

Ans : (B)

Ionic compounds do not conduct electricity in the solid state because their constituent ions are held tightly in a rigid crystal lattice. When dissolved

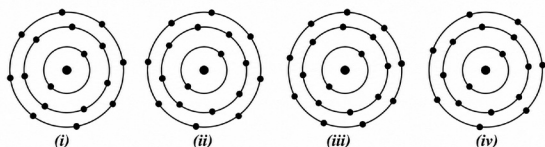
6. Write the formulae of the compounds formed from the following pairs of ions.

- (i) Ca^{2+} and Br^-
 (ii) Al^{3+} and CO_3^{2-}
 (iii) K^+ and SO_4^{2-}
 (iv) NH_4^+ and Cl^-

Ans :

- (i) CaBr_2
 (ii) $\text{Al}_2(\text{CO}_3)_3$
 (iii) K_2SO_4
 (iv) NH_4Cl

7. Which of the following, in figure correctly represents Cl^- ion (Atomic number of chlorine = 17).



Ans :

(ii) is the correct option. A neutral chlorine atom has an atomic number of 17, meaning its electronic configuration is 2, 8, 7. When it gains one electron to form a stable Cl^- ion, it gets an additional electron in its outermost shell, making its new configuration 2, 8, 8, which is depicted in diagram (ii).

8. Determine the formula unit mass of the following substances.

- (i) Ammonium nitrate (NH_4NO_3), used as a nitrogen fertiliser, which is essential for plant growth.
 (ii) Phosphoric acid (H_3PO_4), used to make phosphate fertiliser and detergents.
 (iii) Sodium hydrogencarbonate (NaHCO_3), used to relieve acidity and helps in digestion.

Ans :

- (i) The atomic masses are
 $\text{N} = 14 \text{ u}$, $\text{H} = 1 \text{ u}$, and $\text{O} = 16 \text{ u}$.
 Formula unit mass of NH_4NO_3
 $= (14) + (4 \times 1) + (14) + (3 \times 16)$
 $= 14 + 4 + 14 + 48 = 80 \text{ u}$.
 (ii) The atomic masses are
 $\text{H} = 1 \text{ u}$, $\text{P} = 31 \text{ u}$, and $\text{O} = 16 \text{ u}$.
 Formula unit mass of H_3PO_4
 $= (3 \times 1) + (31) + (4 \times 16)$
 $= 3 + 31 + 64 = 98 \text{ u}$.

- (iii) The atomic masses are

$\text{Na} = 23 \text{ u}$, $\text{H} = 1 \text{ u}$, $\text{C} = 12 \text{ u}$, and $\text{O} = 16 \text{ u}$.

Formula unit mass of NaHCO_3
 $= (23) + (1) + (12) + (3 \times 16)$
 $= 23 + 1 + 12 + 48 = 84 \text{ u}$.

9. Write the formulae for the compounds formed by the reaction of:

- (i) Magnesium and nitrogen
 (ii) Lithium and nitrogen
 (iii) Sodium and sulfur
 (iv) Aluminium and oxygen

Ans :

- (i) Mg_3N_2
 (ii) Li_3N
 (iii) Na_2S
 (iv) Al_2O_3

10. Complete the Table 9.3 by writing the formulae of the compounds formed by the cations on the left and the anions at the top. LiNO_3 is given as an example.

	NO_3^-	SO_4^{2-}	PO_4^{3-}
NH_4^+			
Li^+	LiNO_3		
Al^{3+}			
Cu^{2+}			

Ans :

The completed table is as follows:

Cation \ Anion	NO_3^-	SO_4^{2-}	PO_4^{3-}
NH_4^+	NH_4NO_3	$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_3\text{PO}_4$
Li^+	LiNO_3	Li_2SO_4	Li_3PO_4
Al^{3+}	$\text{Al}(\text{NO}_3)_3$	$\text{Al}_2(\text{SO}_4)_3$	AlPO_4
Cu^{2+}	$\text{Cu}(\text{NO}_3)_2$	CuSO_4	$\text{Cu}_3(\text{PO}_4)_2$

11. 5.3 g of sodium carbonate and 6.0 g of acetic acid react to produce 2.2 g of carbon dioxide, 0.9 g of water, and 8.2 g of sodium acetate. Verify whether the law of conservation of mass is valid.

Ans :

The law of conservation of mass states that the total mass of reactants must equal the total mass of products.

chemical properties characteristic of that specific substance, whether it is an elemental gas or a complex chemical compound.

- 29.** Why do highly reactive atomic elements like simple hydrogen and corrosive chlorine naturally prefer to strongly combine and actively form stable chemical molecules?

- (A) Because their respective outermost valence shells currently possess significantly less than eight electrons, and combining practically helps them attain a highly stable electronic configuration.
 (B) Because they naturally contain far too many internal protons, and combining physically reduces their heavy atomic nuclear mass.
 (C) Because both elements possess a completely filled, naturally stable outer octet, making them inherently desire physical expansion.
 (D) Because their heavy central nuclei logically repel each other, accidentally forcing their outer electrons to permanently fuse.

Ans : (A)

Atoms naturally strive for maximum stability, which is typically achieved by obtaining a completely full valence shell. Because highly reactive elements like hydrogen and chlorine fundamentally lack a stable octet or duplet configuration, they readily interact. They share their outermost electrons to effectively complete their shells and reach a stable, lower-energy state.

- 30.** Which of the following specific descriptive statements most accurately defines the fundamental scientific nature of a strong covalent bond?

- (A) It is formed purely by the absolute physical transfer of one or more valence electrons permanently from a metal to a non-metal.
 (B) It is formed exclusively by the mutual sharing of a few or all of their outermost valence electrons strictly between interacting atoms.
 (C) It is a massive invisible electrostatic force that only holds positively charged cations completely together inside solid crystals.
 (D) It is a weak physical attraction that temporarily occurs when neutral atoms accidentally collide at very low temperatures.

Ans : (B)

A true covalent bond fundamentally represents a specific type of chemical interaction where

two interacting atoms directly share pairs of their outermost valence electrons. This mutual sharing powerfully attracts both atomic nuclei simultaneously, securely holding the atoms together to create a highly stable and electrically neutral molecular entity called a molecule.

The table presents the subatomic particle count for four different chemical species. Which combination correctly identifies a cation and an anion from the given species?

Chemical Species	Number of Protons	Number of Electrons	Number of Neutrons
Species W	11	10	12
Species X	8	10	8
Species Y	10	10	10
Species Z	17	17	18

- (A) W is a cation, and Z is an anion.
 (B) Y is a cation, and X is an anion.
 (C) W is a cation, and X is an anion.
 (D) X is a cation, and W is an anion.

Ans : (C)

A cation forms when an atom loses electrons, resulting in more protons than electrons, as seen in species W. An anion forms when an atom gains electrons, creating a greater number of electrons than protons, as demonstrated by species X. Species Y and Z have equal protons and electrons, making them neutral atoms.

- 32.** Consider the detailed chemical mechanism describing the successful formation of a typical hydrogen chloride (HCl) molecule:

- Both the hydrogen and chlorine atoms fundamentally need exactly one additional electron each to practically attain highly stable electronic configurations.
- The hydrogen atom completely transfers its sole inner electron permanently to the highly reactive chlorine atom.
- The resulting stable molecular compound is tightly held together strictly by a single mutually shared covalent bond.

Select the correct combination:

- (A) 1 and 2
 (B) 2 and 3
 (C) 1 and 3
 (D) 1, 2, and 3

Ans : (C)

- 75.** What is the scientific term for the oppositely charged species that form when atoms gain or lose electrons?

Ans :

The scientific term for these oppositely charged species is ions, which include positively charged cations and negatively charged anions held by electrostatic attraction forces.

- 76.** Define an ionic bond in the context of chemical interactions between different atoms.

Ans :

An ionic bond is defined as the strong electrostatic force of attraction existing between oppositely charged ions that holds them firmly together within compounds.

- 77.** What is the precise structural composition of a regular three-dimensional crystal lattice of solid sodium chloride?

Ans :

In a completely regular three-dimensional sodium chloride crystal lattice, every single positive sodium ion is uniformly surrounded by exactly six negatively charged chloride ions.

- 78.** What is the general rule for systematically determining the chemical formula of a binary compound?

Ans :

You must write the symbols of the constituent elements and then simply crossover their respective valencies to be written as subscripts below the elements.

- 79.** Write the chemical formula for aluminium sulfate by properly utilizing the criss-cross method.

Ans :

By crossing the valency of three for aluminium and two for sulfate, the precise chemical formula for aluminium sulfate is written as $\text{Al}_2(\text{SO}_4)_3$.

- 80.** Why are chemical brackets fundamentally required while writing the chemical formula for magnesium hydroxide?

Ans :

Brackets are strictly required around the polyatomic hydroxide ion to clearly indicate that

the subscript two applies to both the oxygen and hydrogen atoms entirely.

- 81.** Write the exact chemical formula for the compound formed when carbon completely reacts with chlorine gas.

Ans :

When carbon with a valency of four reacts with chlorine having a valency of one, the correctly formed covalent compound is carbon tetrachloride, CCl_4 .

- 82.** State one difference between typical ionic and covalent compounds regarding their general physical solubility in water.

Ans :

Ionic compounds are generally highly soluble in plain water, whereas most ordinary covalent compounds, like naphthalene or camphor, are typically completely insoluble in water.

- 83.** Give one distinct reason why solid sodium chloride cannot effectively conduct electricity at normal room temperature.

Ans :

Solid sodium chloride cannot conduct electricity because its constituent oppositely charged ions are tightly held in fixed positions by immensely strong inter-ionic electrostatic forces.

- 84.** Under what specific physical condition can a standard ionic compound successfully conduct a continuous electric current?

Ans :

An ionic compound can successfully conduct an electric current only when it is thoroughly dissolved in water or heated into a completely molten state.

- 85.** What is the general physical relationship between the chemical bond type and the melting point of a substance?

Ans :

Substances containing strong ionic bonds generally exhibit extremely high melting points, whereas substances formed by sharing electrons through covalent bonds display considerably lower melting points.

Ans : (A)

The sequential bonding process fundamentally begins when two unstable oxygen atoms physically interact. To overcome their electron deficiency, they must logically share exactly two electron pairs. This critical mutual sharing directly completes their respective valence octets simultaneously. Ultimately, this stabilized structural state represents the newly created strong double covalent bond.

37. Which of the following fundamentally simple chemical compounds possesses a universally recognized traditional common name that completely bypasses formal, strict systematic prefix-based nomenclature rules?

(A) CO_2
(B) SF_6
(C) PCl_3
(D) NH_3

Ans : (D)

Most simple binary covalent compounds strictly follow systematic prefix-based naming conventions. However, several highly common substances possess widely accepted traditional names that completely bypass these formal rules. For instance, the compound theoretically named nitrogen trihydride is almost universally known, recognized, and referred to simply by its common historical name: ammonia.

38. The noble gaseous element neon possesses an exact atomic number of 10. Why does it fundamentally naturally avoid transferring or sharing its outermost valence electrons with any other elements?

(A) Because its central nucleus lacks sufficient stable neutrons to effectively support any external chemical bond formations.
(B) Because its outermost valence shell is naturally completely filled, making it exceptionally stable without any further reactions.
(C) Because it exists purely as a highly charged ionic plasma that violently repels all incoming nearby chemical elements.
(D) Because its internal electrons spin far too slowly to ever successfully interact with outer valence electrons of other distinct atoms.

Ans : (B)

The element neon possesses an atomic number of exactly ten, resulting in an electronic configuration of two electrons in the first shell and

eight in the outermost shell. Because its valence shell holds a completely full, highly stable octet, it fundamentally lacks any chemical tendency to share or transfer electrons.

39. How exactly does a highly reactive neutral sodium atom practically achieve a completely stable electronic configuration when fundamentally bonding with a reactive chlorine atom?

(A) It permanently accepts exactly one extra valence electron to rapidly become a massive, negatively charged sodium anion.
(B) It mutually shares exactly two outer valence electrons continuously to securely form a highly robust double covalent bond.
(C) It willingly donates its single outermost valence electron completely to rapidly become a highly stable, positively charged sodium cation.
(D) It physically splits its heavy atomic nucleus in absolute half to instantly release vast amounts of intense electrostatic bonding energy.

Ans : (C)

A neutral sodium atom contains just one single electron in its outermost shell. To achieve maximum chemical stability, it willingly donates this lonely valence electron completely. This total loss of negative charge firmly transforms the neutral atom into a positively charged sodium cation, leaving it with a stable inner octet.

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40. The incredibly intense, highly stable electrostatic force of attraction strictly occurring between two completely oppositely charged ions that strongly holds them permanently together is officially called:

(A) A purely physical magnetic force
(B) A strong covalent bond
(C) A strong ionic bond
(D) A weak intermolecular force

Ans : (C)

When metallic atoms completely transfer their valence electrons to non-metallic atoms, they instantly generate positively charged cations and negatively charged anions. The intense electrostatic force of attraction that inherently pulls these oppositely charged ions tightly together to form an extremely stable chemical compound is scientifically defined as an ionic bond.

In a hydrogen chloride molecule, both participating elements strictly require one additional electron to completely fill their respective valence shells. Therefore, instead of a complete electron transfer, they mutually share a single pair of electrons. This specific cooperative action directly forms a highly stable single covalent bond between the two distinct atoms.

33. Following universally accepted chemical nomenclature prefix rules, what is the officially correct, fully systematic chemical name for the complex covalent compound bearing the specific chemical formula N_2O_5 ?
- (A) Nitrogen pentoxide
(B) Dinitrogen pentoxide
(C) Dinitrogen tetraoxide
(D) Nitrogen oxide

Ans : (B)

When scientifically naming complex binary covalent compounds, specific numerical prefixes are extensively utilised to indicate atom counts accurately. For the chemical formula containing two nitrogen atoms and five oxygen atoms, the prefix 'di' denotes two nitrogens, while 'penta' denotes five oxygens. Therefore, the officially correct systematic chemical name is precisely dinitrogen pentoxide.

34. According to strict scientific naming conventions for binary molecular substances, why is the highly toxic chemical compound CO universally named carbon monoxide rather than monocarbon monoxide?
- (A) Because carbon is exclusively a highly reactive metal, and metals absolutely never require any numerical prefixes in names.
(B) Because the prefix 'mono-' is typically, widely, and practically omitted specifically for the very first element in the compound's written formula.
(C) Because oxygen intrinsically dictates the full naming sequence, completely forcing carbon to instantly drop all its formal numerical prefixes.
(D) Because the word monocarbon is linguistically far too difficult for professional chemists to practically pronounce during rapid laboratory work.

Ans : (B)

According to standard chemical nomenclature rules for covalent molecules, specific numerical

prefixes indicate exact atom quantities. However, a major widespread convention explicitly dictates that the prefix 'mono' is permanently omitted when describing the very first element. Thus, a compound containing one carbon and one oxygen is simply named carbon monoxide.

35. Match the specific binary covalent compound chemical formulas listed in List-I precisely with their officially correct systematic prefix-based chemical names detailed in List-II.

	List-I		List-II
P.	PCl_3	1.	Dinitrogen tetroxide
Q.	SF_6	2.	Phosphorus trichloride
R.	N_2O_4	3.	Carbon disulfide
S.	CS_2	4.	Sulfur hexafluoride

- (A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-1, Q-3, R-2, S-4
(D) P-3, Q-1, R-4, S-2

Ans : (A)

Standard naming rules strictly apply specific prefixes based on atomic counts. Phosphorus combining with three chlorines predictably forms phosphorus trichloride. Sulfur reacting with six fluorines accurately generates sulfur hexafluoride. Two nitrogens bonding with four oxygens correctly yield dinitrogen tetroxide. Finally, one carbon bonding with two sulfurs properly produces carbon disulfide.

36. Arrange the following critical sub-atomic events in the correct chronological order to accurately describe the natural formation of a stable oxygen molecule:
- Both participating atoms successfully attain a highly stable, completely filled outer octet configuration.
 - A remarkably strong, electrically neutral double covalent bond is permanently established.
 - Two individual, highly unstable oxygen atoms, each lacking exactly two outermost valence electrons, physically interact.
 - The two approaching atoms mutually share exactly two separate pairs of their outer valence electrons.
- (A) 3, 4, 1, 2
(B) 4, 3, 2, 1
(C) 3, 1, 4, 2
(D) 1, 4, 3, 2

2. Write the actual numerical charges physically under the respective atomic symbols rather than incorrectly as floating superscripts.
3. Systematically crossover the numerical charges downwards to logically obtain the final formula subscript ratios.
4. Always completely multiply the final formula subscripts by a random factor of two to physically ensure a vastly stable giant molecule.

Select the correct combination:

- (A) 1, 2, and 4
- (B) 2, 3, and 4
- (C) 1, 2, and 3
- (D) 1, 3, and 4

Ans : (C)

Writing ionic formulae systematically requires listing the cation's symbol first, followed immediately by the anion. One then writes their respective numerical charges underneath. These specific numerical values are then crisscrossed to determine the subscript ratios. Multiplying subscripts arbitrarily is totally incorrect; rather, they should always be simplified to lowest terms.

46. What is the absolutely correct, completely balanced final chemical formula specifically for the ionic compound aluminium oxide, correctly considering the standard positive valency of aluminium is exactly 3 and the negative valency of oxygen is precisely 2?
 - (A) AlO
 - (B) Al_3O_2
 - (C) Al_2O_3
 - (D) AlO_3

Ans : (C)

To accurately construct the chemical formula for aluminium oxide, one must identify the constituent ions. Aluminium predictably forms a cation with a positive three charge, while oxygen forms an anion with a negative two charge. By effectively crisscrossing these numerical charge values, the final balanced chemical formula naturally becomes Al_2O_3 .

47. Why are specific parentheses or brackets absolutely strictly required when correctly writing the chemical formula for the complex ionic compound aluminium hydroxide, $\text{Al}(\text{OH})_3$?
 - (A) To visually make the very long formula look substantially neater and highly professional on standard written paper.

- (B) To clearly indicate that the final subscript 3 physically applies universally to both the oxygen and hydrogen atoms of the entire polyatomic hydroxide ion.
- (C) To permanently separate the highly reactive metallic aluminium perfectly from the deeply unstable, explosive hydroxide gas.
- (D) To effectively show that the entire structural compound is a massive discrete single molecule rather than a continuous solid crystal lattice.

Ans : (B)

The structurally complex hydroxide ion is a polyatomic entity consisting of one oxygen and one hydrogen atom. Because a single aluminium ion firmly requires exactly three separate hydroxide ions to achieve electrical neutrality, brackets strictly enclose the OH group. This guarantees the subscript accurately multiplies the entire polyatomic group uniformly.

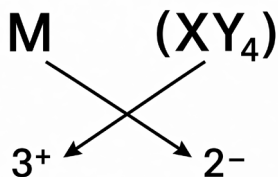
48. During the natural formation of solid calcium carbonate, the respective structural valencies of the positive calcium ion and the negative carbonate ion are both exactly 2. What is the officially correct simplified final chemical formula?
 - (A) Ca_2CO_3
 - (B) $\text{Ca}(\text{CO}_3)_2$
 - (C) $\text{Ca}_2\text{C}_2\text{O}_6$
 - (D) CaCO_3

Ans : (D)

The calcium cation has a positive charge of two, while the complex polyatomic carbonate anion possesses a negative charge of two. When these identical numerical values are formally crisscrossed, they initially yield subscripts of two. However, standard chemical rules strictly dictate dividing by their common factor, yielding the formula CaCO_3 .

49. Based on standard specific laboratory solubility experiments, which of the following statements perfectly describes the highly general solubility behaviour of standard non-polar covalent compounds like solid camphor and pure naphthalene?
 - (A) They are completely highly soluble in liquid water but incredibly insoluble in all liquid organic solvents.
 - (B) They are generally completely insoluble when mixed with water but readily dissolve perfectly in non-polar kerosene and common petrol.

41. Using the valency cross-over method depicted, what is the correct chemical formula for the compound formed by cation M and polyatomic anion (XY_4) ?



- (A) $M_3(XY_4)_2$
 (B) $M_2(XY_4)_3$
 (C) M_2XY_4
 (D) M_3XY_4

Ans : (B)

To write the chemical formula, the valencies of the combining species are criss-crossed and written as subscripts. The valency of M is 3, and the valency of the polyatomic ion (XY_4) is 2. Criss-crossing these values gives M a subscript of 2 and (XY_4) a subscript of 3, yielding $M_2(XY_4)_3$.

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42. **Assertion (A):** Typical solid ionic compounds like sodium chloride naturally exist as purely discrete, highly isolated single molecular units at standard room temperature.

Reason (R): The constituent oppositely charged chemical ions are structurally arranged in a highly regular, infinitely repeating 3-dimensional geometric pattern formally known as a crystal lattice.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (D)

Ionic compounds absolutely do not exist as isolated single molecular units. Instead, they naturally form extensive, highly ordered three-dimensional structures. Within this complex solid arrangement, known formally as a crystal lattice, countless oppositely charged ions are continuously surrounded by each other in a strictly regular and infinitely repeating geometric pattern.

43. Which of the following specific, highly detailed statements explicitly represents an absolutely incorrect rule when formally attempting to name complex ionic compounds?

- (A) The full name of the positively charged cation is fundamentally always written first.
 (B) The official names of simple monatomic anions universally end with the specific suffix '-ide'.
 (C) The name of the negatively charged anion is strictly written completely first, followed sequentially by the name of the cation.
 (D) Ionic compounds are typically naturally formed when reactive metals chemically combine directly with active non-metals.

Ans : (C)

Standard chemical nomenclature strictly dictates that when formally naming any ionic compound, the name of the positively charged cation must always be written first. This is immediately followed by the correctly modified name of the negatively charged anion. Reversing this specific sequential order directly violates fundamental internationally recognized chemical rules.

44. Based on the standard chemical data representing highly common polyatomic chemical ions, what is the precise exact chemical formula and corresponding numerical valency of the standard sulfate ion?

- (A) SO_3^{2-} , valency 3
 (B) SO_4^{2-} , valency 2
 (C) S^{2-} , valency 2
 (D) HSO_4^- , valency 1

Ans : (B)

According to the specific data provided in the textbook's polyatomic ions table, the highly common sulfate ion possesses the exact chemical formula SO_4^{2-} . This clearly indicates it reliably carries a net negative charge of two. Consequently, its official chemical valency, representing its bonding capacity during compound formation, is exactly two.

45. Which of the following fundamental sequential steps are absolutely correctly involved in accurately writing the strict chemical formula of any given ionic compound?

1. Write the precise chemical symbol of the central cation first, followed immediately by the symbol of the specific anion.

53. What is the fundamental, practically strictly scientific primary internal structural reason that typical dense ionic compounds characteristically heavily boast significantly and incredibly high internal melting and final boiling points?

- (A) They possess virtually absolute zero internal physical structural mass, requiring immense heavy physical external pressure to melt.
- (B) They possess remarkably weak external intermolecular forces that easily require absolutely zero heat energy to cleanly break.
- (C) They have incredibly strong, pervasive inter-ionic electrostatic attractions that strictly require applying massive amounts of intense external thermal heat energy to finally structurally break.
- (D) They are primarily fundamentally physically structurally composed purely of highly reactive isolated gases at standard room temperature.

Ans : (C)

Inside any standard solid ionic crystal lattice, millions of continuously alternating positively and negatively charged ions strongly pull against each other. Overcoming these extremely powerful, pervasive electrostatic binding forces strictly requires applying massive amounts of intense thermal energy. Consequently, these stable crystalline materials boast exceptionally high melting and boiling temperatures.

54. A totally unknown reactive metal element 'M', uniquely practically holding exactly two valence electrons purely within its outermost shell, successfully violently reacts fully with surrounding atmospheric oxygen. What structural chemical bond will most highly likely structurally successfully chemically form, and will its final aqueous solution predictably naturally highly conduct active electricity?

- (A) Covalent bond; no, it totally completely will absolutely not highly naturally conduct electricity.
- (B) Ionic bond; yes, it structurally chemically will predictably highly successfully naturally conduct active electricity.
- (C) Covalent bond; yes, it totally completely will predictably highly successfully naturally conduct active electricity.
- (D) Metallic bond; no, it structurally chemically will absolutely totally not highly naturally conduct electricity.

Ans : (B)

A typical reactive metal uniquely holding exactly two outer valence electrons will gladly transfer them entirely to a highly electronegative oxygen atom. This complete electron transfer permanently creates a tough, solid ionic bond. Consequently, whenever this strongly ionic metal oxide actively dissolves inside water, it generates highly conductive free ions.

55. Carefully rigorously accurately systematically completely mathematically practically mathematically calculate the total specific structural final total combined complete final molecular molecular internal mass strictly explicitly regarding purely isolated nitric acid (HNO_3), correctly precisely purely explicitly given specific standard atomic masses: strictly exactly $\text{H} = 1 \text{ u}$, exactly specifically $\text{N} = 14 \text{ u}$, perfectly explicitly $\text{O} = 16 \text{ u}$.

- (A) 31 u
- (B) 48 u
- (C) 63 u
- (D) 98 u

Ans : (C)

Calculating total molecular mass fundamentally requires precisely adding the individual atomic masses of every single atom formally present within the molecule. For nitric acid, we systematically add one unit for hydrogen, strictly fourteen units for nitrogen, and exactly forty-eight units representing three oxygens. This rigorous addition yields exactly sixty-three units.

56. Arrange the following logical steps required to write the correct chemical formula of a simple binary covalent compound:

1. Write the numerical valencies of the constituent elements.
 2. Crossover the given valencies and properly write them as identifying subscripts.
 3. Write the standard chemical symbols of the specific constituent elements.
- (A) 2, 1, 3
 - (B) 3, 1, 2
 - (C) 1, 3, 2
 - (D) 3, 2, 1

Ans : (B)

According to standard chemical textbook procedures, one must precisely begin the highly logical formulation process by systematically writing down the atomic symbols. Next, the

practitioner carefully notes their corresponding elemental valencies. Finally, these specific numerical valency values are structurally crisscrossed downwards to correctly become the final identifying molecular subscript ratios.

57. Select the correct sequential order of events describing the successful natural formation of a simple hydrogen molecule:

1. Two individual highly reactive hydrogen atoms physically approach and mutually share their lone valence electrons.
2. A deeply stabilized, robust single covalent bond is effectively created.
3. Both interacting atomic nuclei simultaneously attain a completely stable, fully filled duplet K-shell configuration.

- (A) 2, 1, 3
(B) 1, 3, 2
(C) 3, 2, 1
(D) 1, 2, 3

Ans : (B)

The molecular formation fundamentally starts when two highly reactive hydrogen atoms approach closely and mutually share their lone valence electrons. This sharing directly allows both atomic nuclei to instantly achieve incredibly stable, completely filled duplet configurations simultaneously. This deeply stabilized state represents the newly formed, exceptionally robust single covalent bond.

58. Based on the comprehensive study of the atomic foundations of matter, identify the combination containing only fully correct scientific statements:

1. Overall physical mass is practically perfectly conserved during both normal physical and standard chemical changes within sealed closed systems.
2. The fundamental Law of Constant Proportions dictates that pure molecular water always has a strictly fixed 1:8 hydrogen to oxygen mass ratio.
3. John Dalton originally proposed that all atomic particles are completely indestructible, entirely fundamental solid entities.
4. Standard purely covalent chemical bonds strictly involve the absolute permanent complete transfer of interacting valence electrons.

Select the correct combination:

- (A) 1, 3, and 4
(B) 1, 2, and 4

- (C) 1, 2, and 3
(D) 2, 3, and 4

Ans : (C)

Major foundational chemical experiments consistently verify that mass remains perfectly conserved during normal reactions. Furthermore, specific chemical compounds reliably maintain incredibly strict elemental mass proportions universally. John Dalton brilliantly theorized atoms as permanently indestructible fundamental entities. However, standard covalent bonds inherently involve mutual electron sharing, absolutely never complete electron transfer.

VERY SHORT ANSWER

59. Who proposed the Law of Conservation of Mass and what is its main statement?

Ans :

Antoine Lavoisier proposed this law, which states that matter can neither be created nor destroyed during any chemical reaction that takes place.

60. Why does the mass in an open flask decrease when baking soda reacts with vinegar?

Ans :

The mass decreases because carbon dioxide gas, which is produced during the chemical reaction, escapes from the open flask into the surrounding air.

61. What would you observe when solutions of barium chloride and sodium sulfate are mixed in a closed container?

Ans :

You would observe the formation of a white precipitate of barium sulfate, while the total mass remains unchanged throughout the entire chemical reaction.

62. Define the Law of Conservation of Mass in the context of chemical reactants and products.

Ans :

It states that the total mass of the reactants before a chemical reaction is exactly equal to the total mass of the resulting products.

63. State the Law of Constant Proportions proposed by Joseph Louis Proust.

Ans :

This law states that in any chemical compound, the combining elements are always present in a definite and fixed proportion by their mass.

64. What is the fixed mass ratio of hydrogen and oxygen when they combine to form pure water?

Ans :

In pure water, regardless of its source, hydrogen and oxygen always combine in a fixed mass ratio of exactly one to eight respectively.

65. What is the significance of the Law of Definite Proportions in chemistry?

Ans :

It provides a fundamental foundation for modern chemistry by proving that chemical compounds contain specific elements fixed in identical mass ratios everywhere.

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66. Give one example to illustrate the Law of Constant Proportions apart from water.

Ans :

In carbon dioxide gas, the elements carbon and oxygen always combine in a fixed ratio of three to eight by mass, regardless of origin.

67. What is an atom according to the fundamental postulates of John Dalton's Atomic Theory?

Ans :

According to Dalton's theory, an atom is the tiniest indivisible particle of matter that participates in chemical reactions and cannot be further destroyed.

68. State one difference between atoms of the same element and atoms of different elements according to Dalton.

Ans :

Atoms of a specific given element have identical masses and chemical properties, whereas atoms of different elements possess completely different masses and chemical properties.

69. How does Dalton's atomic theory logically explain the Law of Constant Proportions?

Ans :

It explains this law by stating that atoms combine in ratios of simple whole numbers to form specific compounds with constant relative atom numbers.

70. What causes the formation of a covalent bond between two combining atoms?

Ans :

A covalent bond is formed primarily due to the sharing of one or more pairs of valence electrons between two combining atoms to achieve stability.

71. Describe the chemical structure of an oxygen molecule in terms of its atomic bonding.

Ans :

An oxygen molecule is formed when two distinct oxygen atoms share two pairs of valence electrons, creating a strong double covalent bond between them.

72. Correct the following statement: Nitrogen trichloride is named based on the sharing of metal and non-metal atoms.

Ans :

The correct statement is that nitrogen trichloride is a covalent compound named using a prefix system to indicate the exact number of constituent atoms.

73. Why is it chemically necessary for a chlorine atom to share an electron with another chlorine atom?

Ans :

A chlorine atom possesses exactly seven valence electrons and must share one electron with another atom to completely fill its octet and achieve stability.

74. How is a sodium cation distinctly different from a neutral sodium atom in terms of electrons?

Ans :

A neutral sodium atom contains exactly eleven electrons, whereas a positively charged sodium cation possesses only ten electrons after losing one single valence electron.

- (C) They fundamentally react highly violently when placed in water to rapidly produce intense explosive hydrogen gas.
- (D) They basically form entirely heavy, dense solid precipitates regardless of the specific chemical solvent used in the laboratory.

Ans : (B)

Scientific experiments clearly demonstrate that typical covalent compounds like camphor and naphthalene exhibit distinct solubility properties. These specific organic substances are generally completely insoluble when mixed with water. However, they readily and completely dissolve when placed into non-polar liquid solvents, such as standard commercial kerosene or common liquid automotive petrol.

50. Why do incredibly massive, heavily charged typical solid ionic compounds generally completely fail to conduct any active flow of electricity when sitting strictly in their solid, dry crystalline state?
- (A) Because all their internal electrons have permanently escaped directly into the surrounding outer atmosphere.
- (B) Because their constituent charged ions are physically permanently held completely immobilized in highly fixed positions by incredibly strong electrostatic forces.
- (C) Because they naturally form highly covalent bonds that completely prevent all structural electron sharing.
- (D) Because solid state compounds fundamentally inherently naturally lack any central atomic nuclei.

Ans : (B)

In an entirely solid state, an ionic compound's heavily charged particles cannot move freely. They remain permanently trapped within a highly rigid crystalline framework by incredibly powerful electrostatic attraction forces. Because active electrical conduction fundamentally requires fully mobile charge carriers, these totally immobilized solid ions absolutely cannot conduct electric current.

51. **Assertion (A):** A thoroughly dissolved clear aqueous solution of standard ionic sodium chloride rapidly and easily conducts active electricity.
- Reason (R):** Actively dissolving solid sodium chloride directly in liquid water instantly releases huge amounts of totally free, highly mobile charged ions that perfectly carry the electric charge.

- (A) Both A and R are true and R is the correct explanation of A
- (B) Both A and R are true but R is not the correct explanation of A
- (C) A is true but R is false
- (D) A is false but R is true

Ans : (A)

When solid sodium chloride is actively dissolved in liquid water, the exceptionally strong electrostatic bonds holding its lattice together quickly break apart. This essential dissolution process continuously releases countless mobile sodium cations and chloride anions directly into the solution. These freely moving, highly charged particles thereby enable excellent electrical conductivity.

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52. Solid household sugar is well known to be incredibly highly soluble directly in normal liquid water. Why does its heavily concentrated sweet aqueous solution utterly completely fail to naturally conduct any detectable active electricity?
- (A) Because dissolving specifically consumes all the surrounding water's free internal conductive energy.
- (B) Because pure sugar strictly acts completely as a massive physical barrier that intentionally permanently blocks all incoming external electrical wires.
- (C) Because it fundamentally remains a highly stable neutral molecular covalent compound that totally fails to produce any free moving electrically charged ions in the solution.
- (D) Because the sugar molecules rapidly chemically react directly with the pure water to perfectly form an entirely new, deeply solid non-conductive plastic.

Ans : (C)

Although household sugar readily and completely dissolves within liquid water, it fundamentally remains a highly stable molecular covalent compound. Because this specific physical dissolution totally fails to produce any freely moving, electrically charged ionic particles, the resulting sweet aqueous solution absolutely cannot conduct any measurable form of active electric current.

86. Accurately define the specific molecular mass of any given stable covalent chemical compound.

Ans :

The molecular mass is the precise total mass of a single molecule, accurately calculated by adding the individual atomic masses of all constituent atoms entirely.

87. What is the correct scientific term used for calculating the mass of an ionic compound instead of molecular mass?

Ans :

The correct scientific term specifically used for calculating the mass of an ionic compound is the formula unit mass, rather than calling it molecular mass.

88. What is the accurately calculated overall formula unit mass of solid sodium oxide (Na_2O)?

Ans :

The correctly calculated formula unit mass of sodium oxide is exactly sixty-two unified mass units, derived by adding two sodium atoms and one oxygen atom.

SHORT ANSWER QUESTIONS

89. Explain the law of conservation of mass using the chemical reaction between aqueous barium chloride and sodium sulfate as an illustrative example.

Ans :

The law of conservation of mass states that mass can neither be created nor destroyed in a chemical reaction. The total mass of reactants is always equal to the total mass of products. For example, when aqueous solutions of barium chloride and sodium sulfate are mixed in a sealed flask, a chemical reaction occurs producing a white precipitate of barium sulfate and sodium chloride. If we weigh the flask before and after the reaction, the mass remains exactly the same, experimentally verifying that no matter is lost or gained during the chemical change.

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90. State any three postulates of Dalton's atomic theory and briefly mention how they directly relate to the fundamental laws of chemical combination.

Ans :

John Dalton proposed several key postulates to logically explain the laws of chemical combination. He stated that all matter is composed of tiny, indivisible particles called atoms. He also postulated that atoms can neither be created nor destroyed during a chemical reaction, which beautifully explains the Law of Conservation of Mass. Furthermore, he proposed that atoms of different elements combine in the ratio of simple whole numbers to form specific compounds. This perfectly justifies the Law of Constant Proportions, explaining why elements always combine in fixed mass ratios.

91. What exactly are polyatomic ions? Provide a clear example and accurately explain how their specific valency is carefully used while writing complex chemical formulae.

Ans :

Polyatomic ions are unique, electrically charged clusters consisting of atoms of two or more different elements permanently bonded together, behaving entirely as a single, indivisible entity during chemical reactions. They carry a fixed overall positive or negative charge, which is considered their absolute valency. For example, the sulfate ion comprises one sulfur atom strictly bonded to four oxygen atoms, carrying a net charge of negative two. When systematically writing chemical formulae, this entire polyatomic group is frequently enclosed in protective brackets before expertly criss-crossing its valency to ensure accurate representation.

92. What precisely is a chemical bond? Clearly explain the significant internal energy changes that naturally occur when separate atoms actively combine to form a stable molecule.

Ans :

A chemical bond is the attractive force that effectively holds interacting atoms together as a cohesive unit within a molecule. When separate, unstable atoms physically combine to form a stable compound, a significant energy transformation occurs. The total combined energy of the newly formed molecular system becomes noticeably lower than the sum of the energies of the originally

within a wholly unsealed, freely uncovered glass experimental container?

Ans :

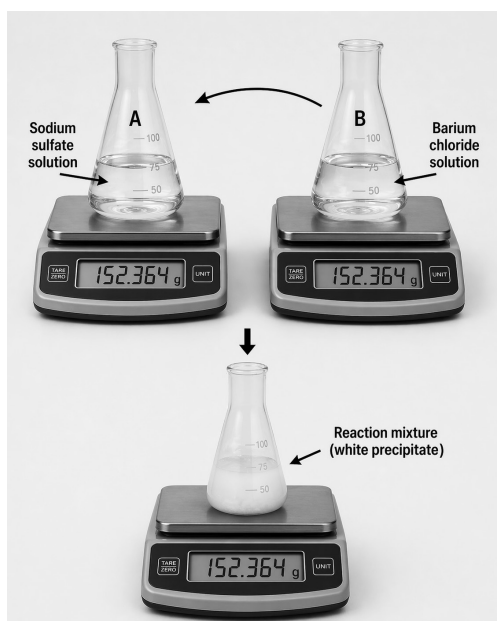
The universal law of conservation of mass firmly dictates that total physical mass undeniably remains perfectly constant throughout any chemical reaction. However, an apparent decrease in measured mass can occasionally happen if a specific experiment is carelessly conducted within an unsealed, fully open container. For example, when reacting acidic vinegar with baking soda, large amounts of invisible carbon dioxide gas are actively generated. If the flask remains uncovered, this newly formed gaseous product effortlessly escapes into the surrounding atmosphere, causing the final recorded scale reading to falsely appear significantly lower than the original mass.

LONG ANSWER QUESTIONS

119. (a) Describe an activity to verify the Law of Conservation of Mass using barium chloride and sodium sulfate?
- (b) In an experiment, 5.3 g of sodium carbonate reacts completely with 6.0 g of acetic acid to yield 2.2 g of carbon dioxide, 0.9 g of water, and some sodium acetate. Calculate the mass of sodium acetate formed?

Ans :

(a)



The Law of Conservation of Mass states that mass can neither be created nor destroyed in a chemical reaction. To verify this, take dilute solutions of sodium sulfate and barium chloride in two separate conical flasks. Place both flasks together on a digital weighing balance to record their combined initial mass. Carefully mix the solutions by pouring one into the other. A reaction occurs, forming a white precipitate of barium sulfate. Weigh both flasks again. The final mass exactly matches the initial reading, confirming mass is conserved.

- (b) For the numerical, the total mass of reactants is the sum of sodium carbonate and acetic acid, which equals 11.3 g. The known products, carbon dioxide and water, add up to 3.1 g. Subtracting the known product mass from the total reactant mass gives the remaining product mass. Therefore, the mass of sodium acetate formed is 8.2 g.

120. (a) What is the Law of Constant Proportions and who proposed it?
- (b) Explain this law using water as an example?
- (c) If 12 g of carbon reacts completely with 32 g of oxygen to form carbon dioxide, calculate how much oxygen will be required to react completely with 6 g of carbon?

Ans :

- (a) Joseph Proust proposed the Law of Constant Proportions, stating that in a chemical compound, elements always combine in a fixed ratio by mass, regardless of their source or preparation method.
- (b) For instance, pure water obtained from a river, well, or laboratory synthesis consistently contains hydrogen and oxygen. The mass ratio of hydrogen to oxygen in water is permanently fixed at 1:8. This means decomposing 9 g of water invariably yields exactly 1 g of hydrogen and 8 g of oxygen.
- (c) In the given numerical problem, 12 g of carbon requires 32 g of oxygen to form carbon dioxide. This establishes a combining mass ratio of 3:8 for carbon and oxygen. Consequently, to find the oxygen needed for 6 g of carbon, we use this fixed proportion. Since 3 g of carbon needs 8 g of oxygen, 6 g of carbon will require 16 g of oxygen to react completely.

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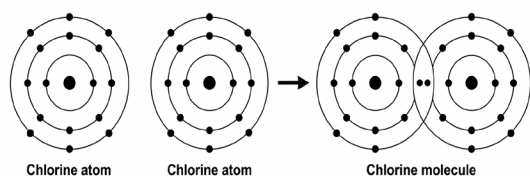
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together the specific atomic masses of every single constituent atom structurally present within that exact molecule. For instance, a water molecule strictly contains exactly two hydrogen atoms and exactly one central oxygen atom. By carefully adding the atomic mass of two hydrogen atoms, equating to two atomic mass units, to the sixteen units of oxygen, we accurately determine its molecular mass as eighteen units.

98. Draw the precise electron sharing process explicitly responsible for forming a completely stable chlorine molecule. Clearly explain exactly what specific type of chemical bond is created here and why this happens.

Ans :



A completely neutral chlorine atom possesses seven electrons in its valence shell, meaning it strictly requires one additional electron to achieve a highly stable octet configuration. When two chlorine atoms interact, neither is willing to permanently lose an electron. Instead, they mutually agree to share one electron each. This sharing creates a single shared pair of electrons situated exactly between the two nuclei. This specific interaction forms a strong single covalent bond, successfully binding the atoms together into a stable diatomic molecule while satisfying the electronic requirements of both.

99. Clearly state the fundamental law of constant proportions. Exactly how does the consistent chemical composition of naturally occurring pure water beautifully illustrate this universally accepted scientific law?

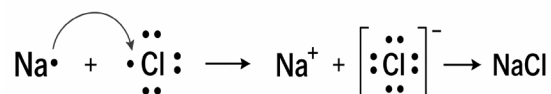
Ans :

The law of constant proportions states that in a chemical compound, the elements are always present in a fixed ratio by mass irrespective of their source. Water always contains hydrogen and oxygen combined in a fixed mass ratio of one to eight. If nine grams of pure water is decomposed, it will always yield one gram of

hydrogen and eight grams of oxygen. Therefore, whether water is obtained from a river, rain, or an ocean, its chemical composition and mass ratio of constituent elements remain absolutely identical.

100. Draw the complete electron transfer process clearly leading to the successful formation of stable sodium chloride. In their resulting solid state, exactly what kind of internal spatial structure do these interacting charged ions naturally form?

Ans :



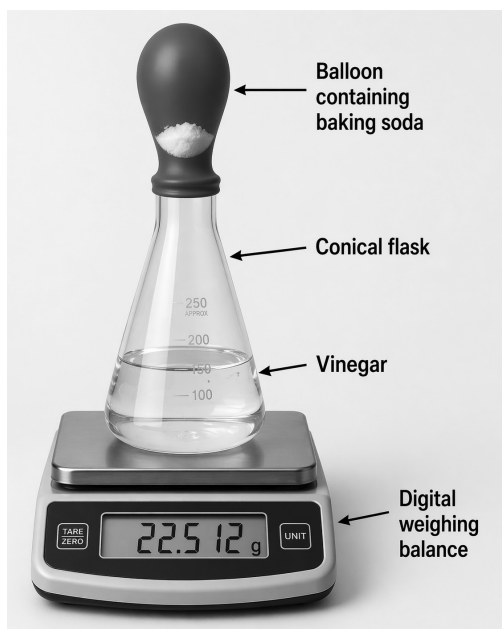
Sodium actively transfers its single outermost valence electron entirely to a waiting chlorine atom, perfectly enabling both elements to achieve highly stable noble gas electronic configurations. This direct transfer remarkably creates a positively charged sodium cation and a negatively charged chloride anion. These oppositely charged ions are subsequently drawn tightly together by overwhelmingly strong electrostatic forces, forming a powerful ionic bond. In their natural solid state, these interacting ions do not remain isolated; instead, they arrange themselves into a vast, highly regular three-dimensional repeating pattern universally known as a crystal lattice structure.

101. What are ionic cations and anions? Accurately explain exactly how these uniquely charged particles are securely held tightly together within a highly stable chemical compound.

Ans :

Cations are positively charged species formed when an atom loses one or more of its valence electrons to achieve structural stability. Anions are negatively charged species formed when an atom gains extra electrons to complete its outermost octet. These oppositely charged ions are drawn together by a remarkably strong electrostatic force of attraction. This powerful invisible force tightly binds the positively charged cations and negatively charged anions in a regular repeating pattern, creating a stable chemical connection known universally as an ionic bond within a crystal lattice.

102. Study the given experimental setup displaying a common chemical activity.



Exactly what is the fundamental scientific purpose of securely keeping the solid baking soda trapped inside the sealed balloon before the active chemical reaction starts? Accurately predict exactly what will predictably happen to the total displayed mass reading after the powder falls into the acidic liquid below.

Ans :

The baking soda is kept in the balloon initially to prevent it from mixing with the vinegar before the starting mass is recorded. This ensures we measure the exact initial mass of the unmixed reactants. When the balloon is lifted and the baking soda falls into the vinegar, a chemical reaction produces carbon dioxide gas. Since the balloon seals the flask, the gas cannot escape. Consequently, the reading on the digital weighing balance will remain unchanged, effectively demonstrating the law of conservation of mass in a closed system.

103. Explain the specific prefix rules formally used for systematically naming simple covalent chemical compounds. Why is a common substance strictly named dihydrogen monoxide usually referred to differently?

Ans :

When systematically naming covalent compounds, a specific prefix system is cleverly used to indicate

the exact number of atoms of each element present. The first element retains its standard name, while the second element crucially ends in 'ide'. Prefixes like mono, di, and tri are strictly applied, though 'mono' is often omitted for the first element. Despite these formal nomenclature rules, a few prevalent binary compounds are universally known exclusively by their traditional common names. For example, dihydrogen monoxide is consistently referred to as water due to historical widespread usage.

104. What exactly does the formula unit mass represent in chemistry? Using given atomic masses, meticulously explain how the accurate formula unit mass of potassium chloride is precisely calculated.

Ans :

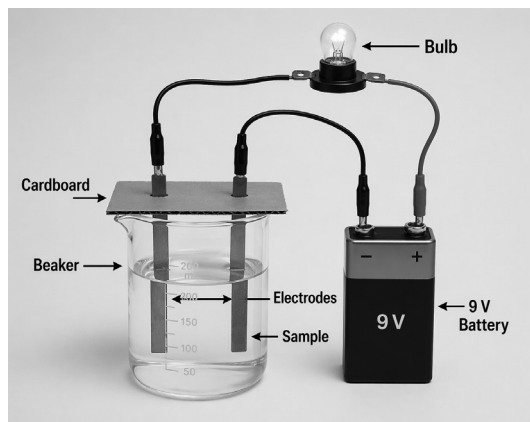
The formula unit mass of a specific ionic compound is precisely defined as the total sum of the atomic masses of all the constituent atoms present in one simplest formula unit of that given substance. This term is explicitly used because ionic compounds fundamentally exist as continuous crystal lattices, not isolated discrete molecules. To accurately calculate the formula unit mass of potassium chloride, we simply add the atomic mass of potassium, which is 39 u, to the atomic mass of chlorine, which is 35.5 u, obtaining a final value of exactly 74.5 u.

105. What is fundamentally defined as a covalent chemical bond? Accurately explain exactly how two separate, highly unstable hydrogen atoms completely interact to miraculously form a completely stable diatomic molecule.

Ans :

A covalent bond is fundamentally defined as a uniquely powerful chemical connection successfully formed by the mutual sharing of valence electrons precisely between two interacting non-metallic atoms. When two individual, unstable hydrogen atoms naturally approach one another, each desperately requires one extra electron to effectively complete a highly stable duplet configuration. Rather than completely transferring electrons, they ingeniously overlap their outer shells and mutually share a single, central pair of negatively charged electrons. This perfectly shared electron pair acts as strong atomic glue, firmly binding the atoms into a remarkably stable diatomic hydrogen molecule.

106. Study the given experimental setup specifically used to accurately test the electrical conductivity of various chemical compounds.



Precisely what distinct visual observation will you make if the liquid test sample inside the beaker is an entirely aqueous solution of sodium chloride? Give a highly detailed scientific reason for your specific proposed answer.

Ans :

If the liquid sample in the beaker is an aqueous solution of sodium chloride, the small light bulb in the circuit will glow brightly. This distinct observation occurs because sodium chloride is a quintessential ionic compound. When it is completely dissolved in water, the solid crystal lattice breaks apart, releasing freely mobile sodium cations and chloride anions throughout the solution. These freely moving charged particles act as carriers, efficiently conducting electric current across the liquid gap between the two inserted metal electrodes, thereby perfectly completing the electrical circuit.

107. What specifically determines the underlying chemical stability of any basic elemental atom? Exactly why do some stable noble elements inherently exist strictly as fiercely independent single atoms rather than clustered molecules?

Ans :

The fundamental chemical stability of any given atom is strictly determined by the total number of valence electrons continuously residing in its absolute outermost shell. Most reactive atoms constantly strive to effectively achieve a completely stable arrangement by acquiring a full set of eight valence electrons, universally known as an octet. However, highly stable elements like

helium innately possess only a single K-shell that reaches maximum possible capacity with exactly two electrons. Because this crucial outermost shell is completely filled naturally, the unreactive atom fundamentally remains perfectly chemically inert.

108. How is a reactive chemical ion fundamentally distinctly different from its totally neutral parent atom? Explain exactly how an isolated neutral sodium atom actively transforms into a highly stable positive ion.

Ans :

An atom is a completely neutral chemical entity because its central nucleus contains exactly the same number of positive protons as orbiting negative electrons. In stark contrast, an ion inherently possesses a definitive electrical charge precisely because it has actively lost or gained specific outer electrons to achieve maximum structural stability. For example, a completely neutral sodium atom innately possesses exactly one unstable valence electron. By willingly transferring this single, loosely bound outer electron away completely, the atom effectively transforms into a remarkably stable, positively charged sodium cation.

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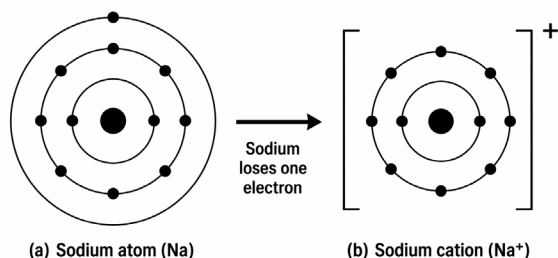
109. A questioning student incorrectly claims that since carbon and oxygen combine differently to completely form both deadly carbon monoxide and harmless carbon dioxide, the fundamental Law of Constant Proportions is basically entirely incorrect. Do you agree with this controversial assertion? Scientifically justify your thoughtful answer.

Ans :

I disagree with the student's claim because the Law of Constant Proportions applies to individual, specific compounds, not to mixtures or different compounds formed by the same elements. Carbon monoxide and carbon dioxide are completely different chemical compounds with distinct properties. In carbon monoxide, carbon and oxygen always combine in a fixed mass ratio of three to four. Conversely, in carbon dioxide, they consistently combine in a mass ratio of three to eight. Therefore, each individual compound perfectly obeys the law by maintaining its own unique, fixed proportion.

110. Draw the detailed internal atomic shell structures of an entirely neutral sodium atom and a successfully formed sodium cation side by side. Precisely why does the initially neutral sodium atom willingly choose to rapidly lose a valuable internal electron entirely during early chemical bond formation?

Ans :



A neutral sodium atom has an atomic number of eleven, giving it an electronic configuration of two, eight, and one. This single electron in its outermost valence shell makes the atom unstable. To achieve a stable, noble gas electronic configuration with a completely filled outermost shell, the sodium atom willingly donates this single valence electron. By losing this negatively charged electron, it is left with eleven protons but only ten electrons. This imbalance in charge transforms the neutral atom into a positively charged sodium cation.

111. A classmate confidently states that basically all normal covalent chemical compounds consistently possess incredibly high melting and boiling points entirely because the shared atomic bonds tightly holding their individual molecules together are overwhelmingly strong. Is this popular assertion truly scientifically correct? Thoroughly justify your firm answer using sound chemical reasoning.

Ans :

I disagree with the student's statement regarding the melting points of covalent compounds. While it is entirely true that the individual atoms inside a covalent molecule are tightly bound together by remarkably strong covalent bonds, the inter-molecular forces of attraction acting between separate molecules are quite weak. When heat is applied to melt or boil a covalent substance, energy is merely needed to overcome these

incredibly weak inter-molecular forces, not to break the strong internal bonds. Consequently, covalent compounds usually possess distinctly low melting and boiling temperatures.

112. Systematically compare solid typical ionic compounds exactly with standard stable covalent compounds entirely based on their vastly different observable macroscopic physical properties regarding general solubility in both pure water and basic organic chemical solvents.

Ans :

Ionic and covalent compounds possess distinctly different physical properties based on their internal bonding. Ionic compounds, such as sodium chloride, are generally highly soluble in water but remain insoluble in organic solvents like petrol or kerosene. In contrast, most covalent compounds, like camphor or naphthalene, show the exact opposite behavior; they are insoluble in water but dissolve easily in organic solvents. Furthermore, ionic compounds boast very high melting and boiling points due to strong inter-ionic attractions, whereas covalent compounds typically exhibit much lower melting and boiling points.

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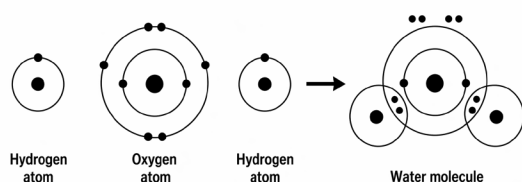
113. Accurately compare exactly how scientists strictly calculate total molecular mass entirely differently from fundamental formula unit mass, carefully highlighting exactly what specific types of solid or liquid chemical compounds these two deeply distinct structural measurement terminologies properly strictly apply to chemically.

Ans :

Molecular mass perfectly applies to covalent compounds composed of distinct, independently existing molecules, such as carbon dioxide or water. It is precisely calculated by simply adding up the specific atomic masses of all the individual atoms present within a single molecule. Conversely, formula unit mass is exclusively used for solid ionic compounds, like sodium chloride, which exist as continuous three-dimensional crystal lattices rather than discrete molecules. It is systematically calculated by taking the sum of the atomic masses of all the interacting ions represented in the compound's simplest formula unit.

114. Carefully draw the completely stable atomic electron sharing arrangement naturally occurring inside a pure single water molecule. Accurately explain precisely why this highly specific chemical compound is universally properly represented strictly as H_2O instead of just HO .

Ans : +



An oxygen atom vitally requires exactly two additional electrons to complete its stable outermost octet, while a single hydrogen atom specifically needs just one extra electron to achieve its stable duplet state. Therefore, it is impossible for one oxygen atom to reach perfect stability by bonding with merely one hydrogen atom. To satisfy its electronic requirement, the central oxygen atom must simultaneously share individual electron pairs with two separate hydrogen atoms. Consequently, the chemical formula strictly dictates the permanent presence of exactly two hydrogen atoms, correctly represented universally as H_2O .

115. Give a completely scientifically sound fundamental reason perfectly explaining exactly why deeply structured solid ionic compounds entirely fail to conduct any functional electricity in their dry unheated state, yet conduct electricity brilliantly and totally efficiently when fully melted or properly thoroughly dissolved continuously in pure water.

Ans :

Ionic compounds consist of positively and negatively charged ions held together by tremendously strong electrostatic forces of attraction in a rigid three-dimensional crystal lattice. In their solid state, these ions are firmly locked in fixed positions and cannot move freely, preventing the conduction of electricity. However, when an ionic compound is dissolved in water or melted into a molten state, the rigid crystal structure breaks down. The ions become completely free to move throughout the solution, allowing them to carry electric current effortlessly and conduct electricity effectively.

116. Accurately describe the exact, sequential, step-by-step scientific method actively involved in correctly predicting and perfectly writing out the entirely balanced structural chemical formula solely for pure stable solid calcium chloride entirely using the standard accepted numerical valency crossover writing technique.

Ans :

To write the chemical formula for calcium chloride, we must follow a systematic sequence of steps. First, we write down the symbols of the constituent elements side by side, placing the metal cation calcium first, followed by the non-metal anion chlorine. Second, we determine and write their respective valencies or charges below the symbols, which is positive two for calcium and negative one for chlorine. Finally, we crossover these valency numbers, ignoring the signs, and write them as subscripts next to the opposite element, resulting in the correct formula.

117. What scientifically disastrous and entirely chaotic massive consequences would hypothetically physically happen to our complex surrounding natural environment if independent combining atoms suddenly began constantly combining entirely in completely random, utterly chaotic numerical mass ratios rather than strictly adhering to constant, predictable fixed chemical proportions?

Ans :

If atoms could combine in any random ratio rather than fixed proportions, the entire foundation of chemistry would collapse. A specific compound like water would no longer exist with consistent, predictable properties. You could have water molecules with varying amounts of oxygen, meaning every sample of water would behave completely differently. This unpredictable combination would make it utterly impossible for complex biological structures or consistent materials to form. The universe would be chaotic, completely lacking the stable, identifiable substances required to sustain life and build our modern world.

118. Exactly why does the entirely measurable total physical mass of an actively reacting chemical system occasionally falsely appear to significantly drastically mysteriously magically strictly decrease during a hot violent gaseous reaction completely occurring openly entirely

- (b) Ionic compounds cannot conduct electricity in the solid state because their constituent ions are tightly locked into a rigid three-dimensional crystal lattice by these strong forces, severely preventing any free movement. However, when the compound is dissolved in water, the rigid lattice effectively breaks apart. This dissolution creates highly mobile charged ions that easily carry electrical current throughout the liquid.

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124. (a) Describe the steps involved in writing the chemical formula of a compound using the criss-cross method?
(b) Apply this method to derive the chemical formulae for aluminium sulfate and calcium carbonate?

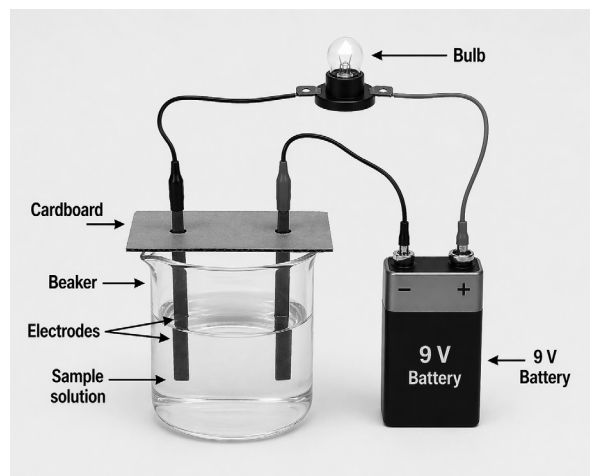
Ans :

- (a) Writing a chemical formula using the criss-cross method requires a systematic sequence of steps. First, write the symbol of the cation on the left side, followed by the symbol of the anion on the right. Next, write the specific valency or charge directly below each corresponding symbol. Finally, crossover these valency numbers and write them as subscripts after the respective symbols to obtain the simplest ratio.
- (b) For aluminium sulfate, the symbol for aluminium is Al with a charge of 3+, while the sulfate ion is SO_4 with a charge of 2-. Criss-crossing these charges yields the formula $\text{Al}_2(\text{SO}_4)_3$, where brackets indicate three entire sulfate groups. For calcium carbonate, calcium is Ca with a 2+ charge and carbonate is CO_3 with a 2- charge. Since both valencies are numerically equal, they automatically simplify to a balanced one to one ratio, resulting in the final formula CaCO_3 .

125. (a) Draw a labelled experimental setup to test the electrical conductivity of a solution?
(b) Using this setup, what observations would you expect when testing solutions of copper sulfate and sugar?
(c) Provide a scientific reason for the difference in their conductivities?

Ans :

(a)



- (b) When testing electrical conductivity using the described setup, different observations are made depending on the nature of the dissolved compound. If a solution of copper sulfate is placed in the beaker, the light bulb will glow brightly. Conversely, if a sugar solution is tested, the bulb will not illuminate at all.
- (c) The scientific reason for this dramatic difference lies in the types of chemical bonds present. Copper sulfate is an ionic compound, meaning it completely dissociates into mobile positively charged copper cations and negatively charged sulfate anions when dissolved in water. These free-moving ions carry the electric charge through the liquid, completing the circuit. Sugar, however, is a covalent compound formed by electron sharing. It dissolves in water as intact, neutral molecules rather than splitting into charged ions. Without the presence of mobile charged particles to carry the current, the sugar solution remains an insulator, preventing electricity flow.

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126. (a) Differentiate between molecular mass and formula unit mass?
(b) Calculate the molecular mass of nitric acid (HNO_3) and the formula unit mass of magnesium hydroxide ($\text{Mg}(\text{OH})_2$). (Given atomic masses: H = 1 u, N = 14 u, O = 16 u, Mg = 24 u)?

121. (a) State the postulates of Dalton's atomic theory that explain the Law of Conservation of Mass and the Law of Constant Proportions?
- (b) How does Dalton's theory support the indivisibility of atoms?

Ans :

- (a) Dalton's atomic theory provides a theoretical foundation for chemical combination laws through specific postulates. The postulate explaining the Law of Conservation of Mass states that atoms are indivisible particles which can neither be created nor destroyed in a chemical reaction. During any reaction, atoms merely rearrange to form new substances, keeping the total mass completely constant. Furthermore, the postulate explaining the Law of Constant Proportions asserts that the relative number and types of atoms remain strictly uniform within a given compound. Because compounds form when distinct atoms combine in fixed whole-number ratios, their mass composition naturally remains permanent.
- (b) Dalton fundamentally supported the indivisibility of atoms by defining them as the ultimate, smallest building blocks of matter. He asserted these fundamental microscopic particles could not be further subdivided by any existing chemical or physical means, thus serving as the indestructible foundation for all chemical combinations and subsequent reactions.

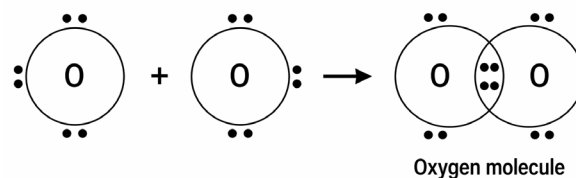
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122. (a) What is a covalent bond?
- (b) Draw the electron dot diagram to show the formation of an oxygen molecule (O_2)?
- (c) Why do covalent compounds generally have low melting and boiling points?

Ans :

- (a) A covalent bond is a type of chemical interaction formed by the sharing of valence electrons between atoms. This sharing allows each participating atom to achieve a stable electronic configuration similar to a noble gas.

(b)



In an oxygen molecule, each oxygen atom possesses six valence electrons and requires two additional electrons to complete its octet. Consequently, two oxygen atoms share two pairs of electrons, resulting in a strong double covalent bond that securely holds the molecule together.

- (c) Covalent compounds typically exhibit low melting and boiling points because they consist of distinct, electrically neutral molecules rather than a lattice of charged ions. While the covalent bonds holding individual atoms together within a single molecule are extremely strong, the intermolecular forces acting between separate molecules are relatively weak. Therefore, only a small amount of thermal energy is required to overcome these weak forces and change the physical state of the substance.
123. (a) Explain the formation of an ionic bond with reference to sodium chloride?
- (b) Why do ionic compounds generally conduct electricity in an aqueous solution but not in a solid state?

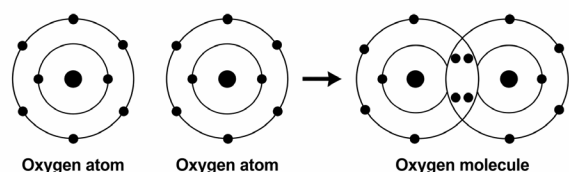
Ans :

- (a) An ionic bond forms through the complete transfer of valence electrons from one atom to another. For instance, a neutral sodium atom has one valence electron, while a chlorine atom has seven. Sodium willingly donates its single electron to achieve a stable electronic configuration, becoming a positively charged sodium cation. Simultaneously, chlorine readily accepts this donated electron to complete its octet, becoming a negatively charged chloride anion. The remarkably strong electrostatic force of attraction between these oppositely charged ions creates the ionic bond holding sodium chloride together.

isolated individual atoms. This crucial reduction in internal energy fundamentally makes the resulting atomic arrangement substantially more stable, completely satisfying the natural universal tendency toward minimum energy.

93. Draw the complete electron dot formation process of a stable diatomic oxygen molecule. Thoroughly explain exactly why a specifically double bond must be formed directly between the two identical reacting oxygen atoms.

Ans :



An oxygen atom has an atomic number of eight, which means it has six electrons in its outermost valence shell. To achieve a stable electronic configuration and complete its octet, it requires two additional electrons. When two oxygen atoms approach each other, they each share two valence electrons. This sharing of two electron pairs forms a strong double covalent bond holding the atoms together. Through this mutual sharing, both oxygen atoms attain the stable electronic configuration of a noble gas, resulting in the formation of a stable oxygen molecule.

94. Carefully explain the specific rules for systematically writing the exact chemical formula of an ionic compound containing a polyatomic ion, using aluminium sulfate as an example.

Ans :

When systematically writing the complex chemical formula for an ionic compound containing polyatomic ions, precise valency criss-crossing rules strictly apply. For aluminium sulfate, we first distinctly write the aluminium cation symbol, strictly followed by the polyatomic sulfate anion symbol. We accurately identify aluminium's positive valency as three and the intact sulfate group's negative valency as two. Upon skillfully crossing over these designated charges as lowercase subscripts, the entire polyatomic sulfate cluster must be carefully enclosed within protective brackets before placing the subscript three, ultimately yielding the perfectly balanced formula format.

95. Explain the scientific concept of formula unit mass. Why is this specific terminology universally preferred over molecular mass when discussing the internal composition of solid ionic compounds?

Ans :

The formula unit mass of a compound is the exact sum of the atomic masses of all individual ions present within its simplest formula unit. This specific terminology is universally used exclusively for solid ionic compounds, like sodium chloride, because they fundamentally exist as continuous, deeply interconnected three-dimensional crystal lattices rather than independent, discrete molecules. By correctly adding the precise atomic masses of the specific positively charged cations and negatively charged anions in the simplest whole-number ratio, chemists can easily calculate the compound's accurate total mass value.

96. Accurately explain why solid ionic compounds generally possess extremely high melting and boiling points compared to simple covalent compounds, referencing their specific internal atomic structural arrangement.

Ans :

Solid ionic compounds consistently exhibit remarkably high melting and boiling points due to the inherent physical nature of their internal structure. They are completely composed of distinctly positive cations and totally negative anions arranged in a rigid, highly stable three-dimensional crystal lattice. These continuously alternating ions are tightly bound together by immensely powerful electrostatic forces of inter-ionic attraction. Consequently, an incredibly massive amount of external thermal energy is absolutely required to successfully overcome these dominant attractive forces and effectively break the rigid crystal structure into a freely flowing liquid phase.

97. Define the scientific term molecular mass. Provide a clear, step-by-step written explanation describing exactly how the total molecular mass of a single pure water molecule is accurately calculated.

Ans :

Molecular mass perfectly represents the precise total mass of a single, independently existing molecule of a given covalent compound. It is meticulously calculated by accurately adding

Ans :

- (a) Molecular mass is the sum of the atomic masses of all atoms present in a single molecule of a covalent compound. It applies to substances existing as discrete molecules. Conversely, formula unit mass is used exclusively for ionic compounds, which form three-dimensional crystal lattices rather than individual molecules. It is determined by summing the atomic masses of all ions present in the simplest stoichiometric ratio, called the formula unit.
- (b) To find the molecular mass of nitric acid, we add the atomic masses of one hydrogen, one nitrogen, and three oxygen atoms. This calculation is 1 u plus 14 u plus 48 u, which exactly equals 63 u. For the formula unit mass of magnesium hydroxide, we sum the masses of one magnesium atom, two oxygen atoms, and two hydrogen atoms. This calculation is 24 u plus 32 u plus 2 u, resulting in a total formula unit mass of 58 u.

127. (a) Element X has 1 electron in its third shell, while Element Y has 6 electrons in its second shell. Predict the type of bond formed when X and Y combine, and explain the mechanism of this bond formation?
- (b) Write the chemical formula of the resulting compound?

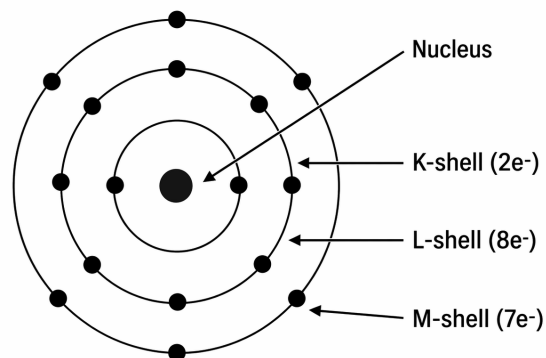
Ans :

- (a) Element X possesses a single valence electron in its outermost third shell. To achieve stability, it completely loses this electron, forming a positively charged cation with a 1+ charge. Conversely, Element Y has six valence electrons in its second shell and requires two additional electrons to complete its octet. Thus, it eagerly accepts electrons to form a negatively charged anion with a 2- charge. When these elements chemically combine, Element X directly transfers its valence electron to Element Y. Because this chemical interaction involves the complete transfer of electrons resulting in oppositely charged ions, the strong connection is defined as an ionic bond.
- (b) To systematically determine the resulting chemical formula, we utilize the criss-cross method. Since X exhibits a combining valency of 1 and Y has a valency of 2, exactly two atoms of X are required to balance one atom of Y, yielding the final formula X_2Y .

128. (a) A chlorine atom has atomic number 17. Draw the atomic structure of a neutral chlorine atom showing its electron shells?
- (b) How does a chloride ion differ from a neutral chlorine atom in terms of subatomic particles and stability?
- (c) Why do inert gases like neon not form ions?

Ans :

- (a)



Atomic structure of chlorine atom

- (b) A neutral chlorine atom possesses exactly seventeen protons in its central nucleus and seventeen electrons distributed across its electron shells. However, its outermost valence shell contains only seven electrons, making it structurally unstable. To achieve a stable noble gas configuration, the neutral atom gains one additional electron from another element. This transformation creates a chloride ion. While the central nucleus retains the original seventeen positively charged protons, the electron count increases to eighteen. This imbalance results in a net negative charge, turning it into a stable anion with a complete octet.
- (c) Unlike chlorine, inert gases such as neon naturally possess a completely filled outermost valence shell. Neon contains exactly eight electrons in its valence shell, perfectly fulfilling the octet rule. Because their electron configuration is already highly stable, they have no chemical tendency to gain, lose, or share electrons. Consequently, inert gases remain entirely unreactive and do not form ions.

154. Hydrogen and oxygen combine in the ratio of 1:8 by mass to form water. What mass of oxygen gas would be required to react completely with 3 g of hydrogen gas?

Ans :

The ratio of masses of hydrogen to oxygen in water is 1:8.

This means:

$$\frac{\text{Mass of Hydrogen}}{\text{Mass of Oxygen}} = \frac{1}{8}$$

Given mass of hydrogen gas = 3 g.

Let the mass of oxygen gas required be $\times$ g.

$$\text{So, } \frac{3 \text{ g}}{\times \text{ g}} = \frac{1}{8}$$

Cross-multiplying, we get:

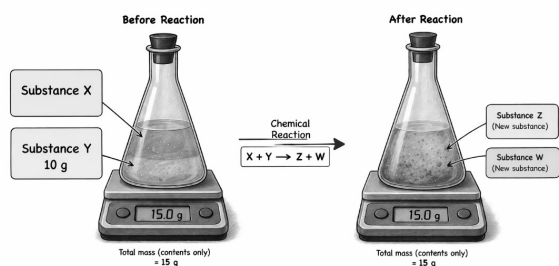
$$\times \times 1 = 3 \times 8$$

$$\times = 24 \text{ g}$$

Therefore, 24 g of oxygen gas would be required to react completely with 3 g of hydrogen gas.

CASE BASED QUESTIONS

155. A scientist performs a chemical reaction in a sealed conical flask. She takes 10 grams of substance X (e.g., copper sulphate solution) and reacts it with 5 grams of substance Y (e.g., sodium carbonate solution). After the reaction, new substances Z and W are formed. The scientist carefully weighs the sealed flask and its contents before and after the reaction and finds that the total mass remains unchanged at 15 grams (excluding the mass of the flask itself).



- Which law of chemical combination is demonstrated by this experiment?
- State the law demonstrated.
- If 3 grams of product Z were formed, what would be the mass of product W formed, assuming X and Y reacted completely?
- Why was it important for the scientist to perform the reaction in a sealed flask for this particular observation?

Ans :

- The Law of Conservation of Mass is demonstrated by this experiment.
- The Law of Conservation of Mass states that mass can neither be created nor destroyed in a chemical reaction.
- If 3 grams of product Z were formed, then 12 grams of product W would be formed (Total mass of reactants = $10\text{g} + 5\text{g} = 15\text{g}$; Mass of products = Mass of Z + Mass of W; $15 = 3\text{g} + \text{Mass of W}$; Mass of W = 12g).
- It was important to perform the reaction in a sealed flask to ensure that no reactants or products (especially if any were gaseous) escaped, and no external substances entered, which would alter the mass reading and invalidate the verification of the law of conservation of mass.

156. John Dalton proposed an atomic theory that revolutionized the understanding of matter. One of the key postulates of his theory was that atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction. He also stated that atoms of a given element are identical in mass and chemical properties, while atoms of different elements have different masses and chemical properties.

- Which law of chemical combination is directly explained by Dalton's postulate that atoms can neither be created nor destroyed?
- According to Dalton's theory, what distinguishes an atom of gold from an atom of silver?
- If atoms are indivisible as Dalton proposed, how did he explain the formation of compounds like water from hydrogen and oxygen? (Hint: Think about another postulate).
- We now know that atoms are further divisible into subatomic particles. Does this completely invalidate Dalton's atomic theory? Explain.

Ans :

- The Law of Conservation of Mass is explained by Dalton's postulate that atoms can neither be created nor destroyed in a chemical reaction; they are merely rearranged.
- According to Dalton's theory, an atom of gold and an atom of silver would differ in their mass and chemical properties.
- Dalton explained the formation of compounds through his postulate that atoms combine in the ratio of small whole numbers to form compounds.

$$C = \frac{12}{100} \times 100 = 12\%$$

$$O = \frac{16 \times 3}{100} \times 100 = 48\%$$

- 136.** 50 g of 10% lead nitrate is mixed with 50 g of 10% sodium chloride in a closed vessel. It was found after reaction that 6.83 g of lead chloride was precipitated. Besides, the reaction mixture contained 90 g water and sodium nitrate. Calculate the amount of sodium nitrate formed.

Ans :

50 g of 10% lead nitrate

$$= 5 \text{ g lead nitrate} + 45 \text{ g water}$$

50 g of 10% sodium chloride

$$= 5 \text{ g sodium chloride} + 45 \text{ g water}$$

Total content before reaction = 5 + 5 + 90 = 100

Total content after reaction = 90 g

Amount of precipitate = 6.83 g

According to law of conservation,

Total mass of reaction mixture = 100 g

$$\begin{aligned} \text{Amount of sodium nitrate} &= 100 - 90 - 6.83 \\ &= 3.17 \text{ g} \end{aligned}$$

- 137.** The mass of one molecule of a substance is 4.65×10^{23} grams. What is its molecular mass ?

Ans :

Mass of 1 molecule of a substance

$$= 4.65 \times 10^{23} \text{ grams}$$

Mass of 6.023×10^{23} molecules of a substance

$$= 4.65 \times 10^{23} \times 6.023 \times 10^{-23}$$

$$= 28 \text{ g}$$

Molecular mass of the substance = 28 g

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- 138.** Chlorine occurs in nature in two isotopic forms with masses 35u and 37u in the ratio of 3 : 1. What should be the mass of chlorine atom ?

Ans :

Mass of chlorine atom

$$\begin{aligned} 35 \times \frac{75}{100} + 37 \times \frac{25}{100} &= \frac{105}{4} + \frac{37}{4} \\ &= \frac{142}{4} = 35.5\text{u} \end{aligned}$$

- 139.** Calculate the formula unit masses of ZnO, Na₂O, K₂CO₃ given atomic masses of Zn = 65u, Na = 23u, K = 39u, C = 12u, and O = 16u.

Ans :

Formula unit mass of ZnO

$$= 1 \times 65\text{u} + 1 \times 16\text{u}$$

$$= 81\text{u}$$

Formula unit mass of Na₂O

$$= 2 \times 23\text{u} + 1 \times 16\text{u}$$

$$= 62\text{u}$$

Formula unit mass of K₂CO₃

$$= 2 \times 39\text{u} + 1 \times 12\text{u} + 3 \times 16\text{u}$$

$$= 138\text{u}$$

- 140.** If one mole of carbon atoms weighs 12 grams, what is the mass (in gram) of 1 atom of carbon ?

Ans :

1 mole of carbon weighs = 12 g

$$\begin{aligned} 1 \text{ atom of carbon weighs} &= \frac{12}{6.022 \times 10^{23}} \\ &= 1.99 \times 10^{-23} \text{ g} \end{aligned}$$

- 141.** What is the mass of :

- 1 mole of nitrogen atoms ?
- 4 moles of aluminium atoms (atomic mass of aluminium = 27) ?
- 10 moles of sodium sulphite (Na₂SO₃) ?

Ans :

- (a) 1 mole of nitrogen atoms

$$= 1 \times \text{gram atomic mass of nitrogen atom}$$

$$= 1 \times 14 \text{ g} = 14 \text{ g}$$

- (b) 4 moles of aluminium atoms

$$= 4 \times \text{gram atomic mass of aluminium atoms}$$

$$= 4 \times 27 \text{ g} = 108 \text{ g}$$

- (c) 10 moles of sodium sulphite (Na₂SO₃)

$$= 10 (2 \times \text{gram atomic mass of Na}$$

$$+ 1 \times \text{gram atomic mass of sulphur}$$

$$+ 3 \times \text{gram atomic mass of oxygen})$$

$$= 10 (2 \times 23 \text{ g} + 1 \times 32 \text{ g} + 3 \times 16\text{g})$$

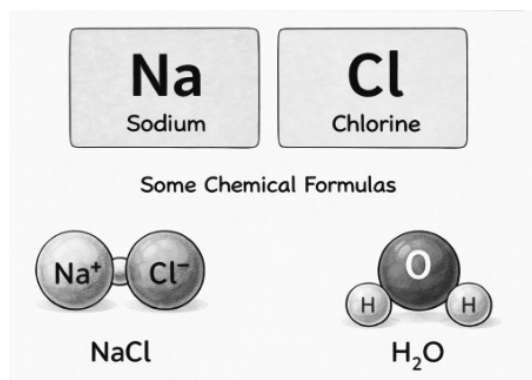
$$= 10 (46 \text{ g} + 32 \text{ g} + 48 \text{ g})$$

$$= 10 \times 126 \text{ g} = 1260 \text{ g}$$

Ans :

1. Molecular mass is the sum of the atomic masses of all the atoms in a molecule of the substance. It is expressed in atomic mass units (u).
2. In one molecule of H_2SO_4 , there are 2 atoms of hydrogen, 1 atom of sulphur, and 4 atoms of oxygen.
3. Molecular mass of $\text{H}_2\text{SO}_4 = (2 \times \text{Atomic mass of H}) + (1 \times \text{Atomic mass of S}) + (4 \times \text{Atomic mass of O})$
 $= (2 \times 1 \text{ u}) + (1 \times 32 \text{ u}) + (4 \times 16 \text{ u})$
 $= 2 \text{ u} + 32 \text{ u} + 64 \text{ u}$
 $= 98 \text{ u}.$
4. For ionic substances like NaCl , the term formula unit mass is generally used. It is calculated in the same way as molecular mass, by summing the atomic masses of all atoms in a formula unit of the compound.

160. A student is learning about chemical symbols and formulas. They see that the symbol for Sodium is 'Na' and for Chlorine is 'Cl'. They also learn that the chemical formula for common salt (sodium chloride) is NaCl , and for water is H_2O .



1. What information does the chemical symbol 'Na' for sodium convey?
2. What does the chemical formula ' H_2O ' for water tell us about the elements present and the number of atoms of each element in one molecule of water?
3. What is the significance of using standardized chemical symbols like those approved by IUPAC?
4. Why is the '2' written as a subscript in H_2O but not in NaCl ?

Ans :

1. The chemical symbol 'Na' represents one atom of the element sodium. It is derived from its Latin name 'Natrium'.

2. The chemical formula ' H_2O ' tells us that one molecule of water is composed of the elements hydrogen (H) and oxygen (O). It also indicates that there are two atoms of hydrogen and one atom of oxygen in each molecule of water.
3. Standardized chemical symbols provide a universal, concise, and unambiguous way for scientists worldwide to communicate about elements and compounds, avoiding confusion that could arise from using different naming conventions or symbols.
4. The subscript '2' in H_2O indicates that there are two atoms of hydrogen combined with one atom of oxygen. In NaCl , there is one atom of sodium combined with one atom of chlorine, so no subscript is needed (a subscript of '1' is implied).

161. A student is given a blue crystalline compound with the formula CuSO_4 . The valency of the copper ion (Cu) in this compound is +2, and the sulphate ion (SO_4) has a charge of -2.

1. What are the constituent elements of copper sulphate?
2. What is a polyatomic ion? Identify the polyatomic ion in CuSO_4 .
3. Following the rules for writing chemical formulas, explain why the formula is CuSO_4 and not $\text{Cu}_2(\text{SO}_4)_2$ or some other variation, given the charges on the ions.
4. If copper also showed a valency of +1 (forming Cu^+), what would be the formula of copper(I) sulphate?

Ans :

1. The constituent elements of copper sulphate are Copper (Cu), Sulphur (S), and Oxygen (O).
2. A polyatomic ion is a group of atoms carrying a charge. In $\text{Cu}_2(\text{SO}_4)_2$, the sulphate ion (SO_4^{2-}) is a polyatomic ion.
3. The copper ion is Cu^{2+} and the sulphate ion is SO_4^{2-} . Since the magnitudes of their charges are equal (+2 and -2), they balance each other in a 1:1 ratio. Thus, the formula is CuSO_4 . The charges must balance to form a neutral compound.
4. If copper has a valency of +1 (Cu^+) and sulphate has a valency of -2 (SO_4^{2-}), then two Cu^+ ions would be needed to balance one SO_4^{2-} ion. So the formula for copper(I) sulphate would be Cu_2SO_4 .

148. Calculate the mass of the following :

- (i) 2 moles of carbon dioxide.
- (ii) 6.022×10^{23} molecules of carbon dioxide.

Ans :

- (i) Molar mass of $\text{CO}_2 = 12 + 2 \times 16 \text{ g}$
 $= 44 \text{ g}$
 1 mole of carbon dioxide = 44 g
 2 mole of carbon dioxide = $44 \text{ g} \times 2$
 $= 88 \text{ g}$
- (ii) Molar mass of $\text{CO}_2 = 44 \text{ g}$
 $= 6.022 \times 10^{23}$ molecules of carbon dioxide

149. Calculate molar mass of sulphuric acid.

Ans :

$$\begin{aligned} \text{Formula of sulphuric acid} &= \text{H}_2\text{SO}_4 \\ \text{Molar mass of } \text{H}_2\text{SO}_4 &= 2 \times \text{mass of H} \\ &+ 1 \times \text{mass of S} + 4 \times \text{mass of O} \\ &= 2 \times 1 + 1 \times 32 + 4 \times 16 \\ &= 2 + 32 + 64 \\ &= 98 \text{ g mol}^{-1} \end{aligned}$$

150. Sunita calculated molecular mass of S_8 molecule and reported it as 64u from the given atomic mass of 32u. But teacher considered her answer as wrong. What is the correct molecular mass of S_8 ? Calculate the number of moles of S_8 in 25.6 g of the sample.

Ans :

$$\begin{aligned} \text{Molecular mass of } \text{S}_8 &= 32 \times 8 = 256\text{u} \\ \text{Moles of } \text{S}_8 \text{ in } 25.6 \text{ g sample} &= \frac{25.6}{256} = 0.1 \text{ mole} \end{aligned}$$

151. Calculate the number of atoms present in (i) an H_2S molecule and (ii) a PO_4^{3-} ion.

Ans :

- (i) In an H_2S molecule:
 There are 2 atoms of Hydrogen (H).
 There is 1 atom of Sulphur (S).
 Total number of atoms = $2 + 1 = 3$ atoms.
- (ii) In a PO_4^{3-} ion (phosphate ion):
 There is 1 atom of Phosphorus (P).
 There are 4 atoms of Oxygen (O).
 Total number of atoms = $1 + 4 = 5$ atoms.
 The charge (3-) on the ion does not affect the count of atoms within the polyatomic ion.

152. A sample of a compound contains 0.24 g of boron and 0.096 g of oxygen by analysis. Calculate the percentage composition of the compound by weight for boron and oxygen.

Ans :

$$\begin{aligned} \text{Given ,} \\ \text{Mass of Boron (B)} &= 0.24 \text{ g} \\ \text{Mass of Oxygen (O)} &= 0.096 \text{ g} \\ \text{Total mass of the compound sample} \\ &= \text{Mass of Boron} + \text{Mass of Oxygen} \\ &= 0.24\text{g} + 0.096\text{g} = 0.336\text{g} \end{aligned}$$

Percentage of Boron

$$= \left(\frac{\text{Mass of Boron}}{\text{Total mass of compound}} \right) \times 100$$

$$= \left(\frac{0.24\text{g}}{0.336\text{g}} \right) \times 100$$

$$\approx 0.71428 \times 100 \approx 71.43\%$$

Percentage of Oxygen

$$= \left(\frac{\text{Mass of Oxygen}}{\text{Total mass of compound}} \right) \times 100$$

$$= \left(\frac{0.096\text{g}}{0.336\text{g}} \right) \times 100$$

$$\approx 0.28571 \times 100 \approx 28.57\%$$

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153. In a reaction, 5.3 g of sodium carbonate reacted with 6.0 g of acetic acid. The products were 2.2 g of carbon dioxide, 0.9 g of water and 8.2 g of sodium acetate. Show that these observations are in agreement with the law of conservation of mass.

Ans :

$$\begin{aligned} \text{Reactants: Sodium carbonate} &+ \text{Acetic acid} \\ \text{Mass of sodium carbonate} &= 5.3 \text{ g} \\ \text{Mass of acetic acid} &= 6.0 \text{ g} \\ \text{Total mass of reactants} &= 5.3\text{g} + 6.0\text{g} = 11.3\text{g} \\ \text{Products: Sodium acetate} &+ \text{Carbon dioxide} + \text{Water} \\ \text{Mass of sodium acetate} &= 8.2 \text{ g} \\ \text{Mass of carbon dioxide} &= 2.2 \text{ g} \\ \text{Mass of water} &= 0.9 \text{ g} \\ \text{Total mass of products} &= 8.2\text{g} + 2.2\text{g} + 0.9\text{g} = 11.3\text{g} \end{aligned}$$

Since the total mass of reactants (11.3 g) is equal to the total mass of products (11.3 g), these observations are in agreement with the law of conservation of mass.

129. Calculate the ratio of the numbers of atoms for magnesium sulphide.

Ans :

$$\text{Atomic mass of Mg} = \frac{3}{24} = \frac{1}{8}$$

$$\text{Atomic mass of S} = \frac{4}{32} = \frac{1}{8}$$

$$\text{Ratio of atoms in MgS} = \frac{1}{8} : \frac{1}{8} \text{ or } 1 : 1$$

130. The mass of any single atom X is 3.05×10^{-22} g. What is its atomic weight ? Name the possible element.

Ans :

$$1 \text{ mole} = 1 \text{ atomic mass}$$

$$= 6.022 \times 10^{23} \text{ atoms}$$

Now, mass of one atom of X

$$= 3.05 \times 10^{-22} \text{ g}$$

Mass of 6.022×10^{23} atoms of X

$$= 3.05 \times 10^{-22} \times 6.022 \times 10^{23} \text{ g}$$

$$= 183.7 \text{ g}$$

This element could be tungsten.

131. A compound formed between element X and element Y always has them in a mass ratio of 2:3. If you react 4g of X with 10g of Y, how much of element Y will remain unreacted?

Ans :

$$\text{If 4g of X reacts, it will combine with } \left(\frac{3}{2}\right) \times 4\text{g} = 6\text{g}$$

of Y. Since 10g of Y was available, the amount of Y remaining unreacted will be $10\text{g} - 6\text{g} = 4\text{g}$. This is based on the law of constant proportions.

132. Glucose has the molecular formula $\text{C}_6\text{H}_{12}\text{O}_6$. Calculate:

- Its molecular mass.
- The number of atoms in one molecule of glucose.
- The number of gram molecule in 18 g of glucose.

Ans :

- (a) Molecular mass of $\text{C}_6\text{H}_{12}\text{O}_6$

$$= (6 \times 12\text{u}) + (12 \times 1\text{u}) + (6 \times 16\text{u})$$

$$= 72\text{u} + 12\text{u} + 96\text{u} = 180\text{u}$$

- (b) The number of atoms in one molecule of $\text{C}_6\text{H}_{12}\text{O}_6$

$$= 6 \text{ atoms of C} + 12 \text{ atoms of H}$$

$$+ 6 \text{ atoms of O}$$

$$= 6 + 12 + 6 = 24 \text{ atoms}$$

- (c) Number of gram molecules

$$= \frac{\text{Mass of glucose (g)}}{\text{Molecular mass of glucose (g)}}$$

$$= \frac{18}{180} = 0.1$$

133. What is the mass of (i) 2.5 moles of CO_2 and (ii) 1 mole of water ?

Ans :

- (i) 1 mole of CO_2 = Molecular mass expressed in grams

$$= 1 \times 44 \text{ g}$$

$$2.5 \text{ moles of } \text{CO}_2 = 2.5 \times 44 = 110 \text{ g}$$

- (ii) Mass of the substance

$$= \text{Moles of substance}$$

$$\times \text{Molecular mass in grams}$$

$$\text{Mass of water} = 1 \times 18 \text{ g} = 18 \text{ g}$$

134. Calculate the number of H_2O molecules in one drop of water having a mass of 0.05 g.

Ans :

Number of moles of H_2O in 0.05 g of water

$$= \frac{0.05 \text{ g}}{18 \text{ g}} \text{ (molar mass of water} = 18)$$

$$= \frac{0.05 \text{ g} \times 6.022 \times 10^{23}}{18 \text{ g}}$$

$$= 1.673 \times 10^{23} \text{ molecules}$$

135. What is the mass percentage of different elements in calcium carbonate ? (Atomic mass : Ca = 40, O = 16)

Ans :

Molecular mass of CaCO_3 = At. Mass of Ca + At. Mass of C + 3 $\times$ At. Mass of O

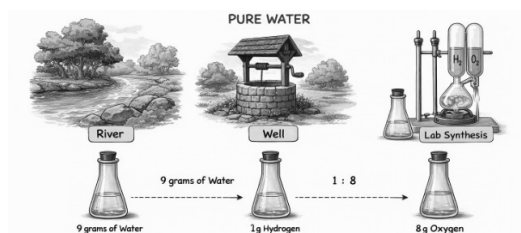
$$= 40 + 12 + 3 \times 16 = 100$$

Mass percentage of Ca

$$= \frac{\text{Mass of element}}{\text{Mass of molecule}} \times 100$$

$$= \frac{40}{100} \times 100 = 40\%$$

4. While the discovery of subatomic particles showed that atoms are divisible, it doesn't completely invalidate Dalton's theory. Many of his postulates, such as atoms being the smallest units participating in chemical reactions and combining in fixed ratios to form compounds, remain fundamental. His theory was a crucial step in the development of modern atomic theory.
157. Scientists analyze samples of pure water collected from different sources: a river, a well, and a laboratory synthesis from hydrogen and oxygen. In every sample of pure water, they find that hydrogen and oxygen are combined in a fixed ratio of 1:8 by mass. For example, 9 grams of water always yields 1 gram of hydrogen and 8 grams of oxygen upon decomposition.



1. Which law of chemical combination is illustrated by this observation about water?
2. State this law.
3. If you have 18 grams of pure water, what mass of hydrogen and oxygen would you expect to obtain upon its complete decomposition?
4. Does this law apply to mixtures like salty water? Why or why not?

Ans :

1. The Law of Constant Proportions (or Law of Definite Proportions) is illustrated.
2. The Law of Constant Proportions states that in a chemical substance, the elements are always present in definite proportions by mass.
3. In 18 grams of pure water, you would expect to obtain 2 grams of hydrogen and 16 grams of oxygen (maintaining the 1:8 ratio).
4. No, this law applies to chemical compounds, not mixtures. In salty water (a mixture), the ratio of salt to water can vary.

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158. Ancient Indian philosopher Maharishi Kanad spoke of 'Parmanu' as the smallest particle of matter (padarth) beyond which further division is not possible. Similarly, Greek philosophers Democritus and Leucippus proposed the idea of 'atoms' (meaning indivisible). These early ideas were philosophical. John Dalton later provided a scientific atomic theory.

1. What was the fundamental idea about matter proposed by both ancient Indian and Greek philosophers regarding its divisibility?
2. What did Dalton call the smallest particles of matter in his theory?
3. How was Dalton's atomic theory different from the earlier philosophical ideas about atoms? (Hint: What was Dalton's theory based on?)
4. According to Dalton, can atoms of different elements be identical? Explain.

Ans :

1. The fundamental idea was that if matter is continuously divided, a stage will eventually be reached where the particles obtained are the smallest possible and cannot be divided further.
2. Dalton also called the smallest particles of matter atoms.
3. Dalton's atomic theory was different because it was based on the laws of chemical combination (like the law of conservation of mass and the law of definite proportions), providing experimental and theoretical backing to the idea of atoms, rather than being purely philosophical.
4. No, according to Dalton's atomic theory, atoms of different elements have different masses and chemical properties. Atoms of a given element are identical.

159. A chemist needs to calculate the molecular mass of sulphuric acid, which has the chemical formula H_2SO_4 . The atomic masses are given as: Hydrogen (H) = 1 u, Sulphur (S) = 32 u, and Oxygen (O) = 16 u.

1. What is meant by molecular mass?
2. How many atoms of hydrogen, sulphur, and oxygen are present in one molecule of sulphuric acid (H_2SO_4)?
3. Calculate the molecular mass of sulphuric acid (H_2SO_4).
4. If a substance is ionic, like sodium chloride (NaCl), what term is generally used instead of molecular mass, and how is it calculated?

- 142.** A sample of ethane (C_2H_6) gas has the same mass as 1.5×10^{20} molecules of methane (CH_4). How many (C_2H_6) molecules does the sample of gas contain?

Ans :

$$\text{Mass of 1 molecule of CH}_4 = \frac{16}{N_A} \text{ g}$$

$$\begin{aligned} \text{Mass of } 1.5 \times 10^{20} \text{ molecule of CH}_4 \\ = 1.5 \times 10^{20} \times \frac{16}{N_A} \text{ g} \end{aligned}$$

$$\text{Mass of 1 molecule of C}_2\text{H}_6 = \frac{30}{N_A} \text{ g}$$

$$\begin{aligned} \text{Mass of } 1.5 \times 10^{20} \text{ molecule of C}_2\text{H}_4 \\ = 1.5 \times 10^{20} \times \frac{16}{N_A} \text{ g} \end{aligned}$$

$$\begin{aligned} \text{Mass of } 1.5 \times 10^{20} \text{ molecule of ethane} \\ = 1.5 \times 10^{20} \times \frac{16}{N_A} \times \frac{N_A}{30} \\ = 0.8 \times 10^{20} \end{aligned}$$

- 143.** (a) Calculate the number of molecules of SO_2 present in 44 g of it.
(b) If one mole of oxygen atoms weighs 16 grams, find the mass of one atom of oxygen in grams.

Ans :

$$\begin{aligned} \text{(a) Molecular mass of SO}_2 &= \text{Atomic mass of S} \\ &+ 2 \times \text{Atomic mass of O} \\ &= 32 + 2 \times 16 = 64\text{u} \end{aligned}$$

$$\text{Molar mass} = 64 \text{ g}$$

$$\text{Number of molecules, N}$$

$$= \text{Given mass} \times \frac{\text{Avogadro's number}}{\text{Molar mass}}$$

$$= \frac{44}{64} \times 6.022 \times 10^{23}$$

$$= 4.14 \times 10^{23} \text{ molecules}$$

- (b) One mole of oxygen contains 6.022×10^{23} atoms of oxygen

$$\begin{aligned} \text{Mass of one atom of oxygen} &= \frac{16}{6.022 \times 10^{23}} \text{ g} \\ &= 2.66 \times 10^{-23} \text{ g} \end{aligned}$$

- 144.** Sodium is represented as $^{23}\text{Na}_{11}$.

- (a) What is its atomic mass ?
(b) Write its gram atomic mass.
(c) How many atoms of Na will be there in 11.5 g of the sample ?

Ans :

$$\text{(a) Atomic mass} = 23\text{u}$$

$$\text{(b) Gram atomic mass} = 23 \text{ g}$$

$$\text{(c) Given mass} = 11.5 \text{ g}$$

$$\text{Molar mass} = 23 \text{ g}$$

$$\text{Number of atoms (N)}$$

$$= \text{Given mass} \times \frac{\text{Avogadro's number}}{\text{Molar mass}}$$

$$= \frac{11.5 \times 6.022 \times 10^{23}}{23}$$

$$= 3.011 \times 10^{23} \text{ atoms}$$

- 145.** Calculate the following in 5.6 g of nitrogen :

$$\text{(a) Number of moles of nitrogen}$$

$$\text{(b) Number of molecules of nitrogen}$$

$$\text{(c) Number of atoms of nitrogen}$$

Ans :

$$\text{(a) Molar mass of nitrogen} = 14 \text{ g}$$

$$5.6 \text{ g of nitrogen} = \frac{5.6}{14} = 0.4 \text{ mole}$$

$$\text{(b) 28 g of nitrogen} = 6.022 \times 10^{23} \text{ molecules}$$

$$5.6 \text{ g of nitrogen} = 2.15 \times 10^{22} \text{ molecules}$$

$$\text{(c) 14 g of nitrogen} = 6.023 \times 10^{23} \text{ atoms}$$

$$5.6 \text{ g of nitrogen} = 4.30 \times 10^{23} \text{ atoms}$$

- 146.** Find the number of atoms in the 0.5 mole of C atom.

Ans :

$$0.5 \text{ mole of C atom} :$$

$$\text{Number of atoms in 1 mole of C atom}$$

$$= 6.022 \times 10^{23} \text{ atoms}$$

$$\text{Number of atoms in 0.5 mole of C atom}$$

$$= 6.022 \times 10^{23} \times 0.5$$

$$= 3.011 \times 10^{23} \text{ atoms}$$

- 147.** What is the mass of :

$$\text{(a) 0.2 mole of oxygen atoms ?}$$

$$\text{(b) 0.5 mole of water molecules ?}$$

Ans :

$$\text{(a) 1 mole of oxygen atoms} = 1 \times 16 = 16 \text{ g}$$

$$0.2 \text{ mole of oxygen atoms} = 16 \text{ g} \times 0.2 = 3.2 \text{ g}$$

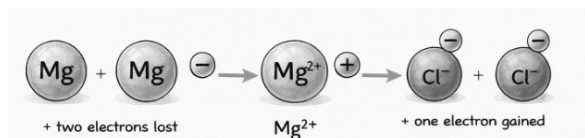
$$\text{(b) 1 mole of water (H}_2\text{O) molecules}$$

$$= 2 \times 1 \text{ g} + 1 \times 16 \text{ g} = 18 \text{ g}$$

$$0.5 \text{ mole of water (H}_2\text{O) molecules}$$

$$= 18 \text{ g} \times 0.5 = 9.0 \text{ g}$$

- 162.** Magnesium (Mg) reacts with Chlorine (Cl) to form an ionic compound, Magnesium Chloride. In this process, a magnesium atom loses two electrons to become a magnesium ion, and each chlorine atom gains one electron to become a chloride ion.



1. What is an ion? What is the difference between a cation and an anion?
2. What will be the charge on the magnesium ion formed? Will it be a cation or an anion? Write its symbol.
3. What will be the charge on the chloride ion formed? Will it be a cation or an anion? Write its symbol.
4. Using the valencies (charges) of the ions, write the chemical formula for Magnesium Chloride.

Ans :

1. An ion is a charged species formed when an atom or a group of atoms loses or gains electrons. A cation is a positively charged ion (formed by loss of electrons), and an anion is a negatively charged ion (formed by gain of electrons).
2. The magnesium ion will have a charge of +2 (since it loses two electrons). It will be a cation. Its symbol is Mg^{2+} .
3. The chloride ion will have a charge of -1 (since it gains one electron). It will be an anion. Its symbol is Cl^- .
4. Magnesium ion (Mg^{2+}) has a valency of 2. Chloride ion (Cl^-) has a valency of 1. To form a neutral compound, one Mg^{2+} ion will combine with two Cl^- ions. The chemical formula for Magnesium Chloride is MgCl_2 .

- 163.** A student named Rahul is preparing for a science exhibition. He decides to test what happens to the weight of substances during a chemical reaction. He places 10 grams of calcium carbonate into a flask containing 7.3 grams of dilute hydrochloric acid. However, he leaves the flask completely open to the air. After the fizzing stops, he places the flask back on the digital weighing balance. He is surprised to see that the total mass of the contents is now less than 17.3 grams. His friend suggests that the missing mass means matter was

destroyed, but his teacher smiles and tells him to think about the bubbles he saw.

QUESTIONS:

- (a) Identify the scientific law Rahul was trying to investigate in his experiment.
- (b) Why did the final mass in Rahul's open flask decrease after the reaction?
- (c) How could Rahul modify his experimental setup to properly verify the law?
- (d) If Rahul performed the experiment perfectly in a closed container, what would the total mass of the products be, and why?

Ans :

- (a) Rahul was trying to investigate the Law of Conservation of Mass, which was proposed by Antoine Lavoisier.
- (b) The final mass decreased because the reaction produced a gas (carbon dioxide), and since the flask was left open, the gas escaped into the atmosphere. The escaped gas carried away some of the mass.
- (c) Rahul should conduct the experiment in a closed system, such as by tightly tying a balloon over the mouth of the flask or sealing it with a cork before the reaction begins, to trap any gases produced.
- (d) In a perfectly closed container, the total mass of the products would be exactly 17.3 grams. This is because, according to the Law of Conservation of Mass, matter can neither be created nor destroyed in a chemical reaction, so the total mass of reactants must equal the total mass of products.

- 164.** During an international space mission, astronauts collected ice samples from a distant asteroid and brought them back to Earth. A team of chemists melted the ice to obtain liquid water and purified it completely. Meanwhile, another team purified water collected from the deep Pacific Ocean. Both teams sent their samples to a lab to find out the ratio of the masses of hydrogen and oxygen present in them. Some journalists wondered if space water would have a completely different chemical makeup compared to Earth water, perhaps containing five times more oxygen than hydrogen.

QUESTIONS:

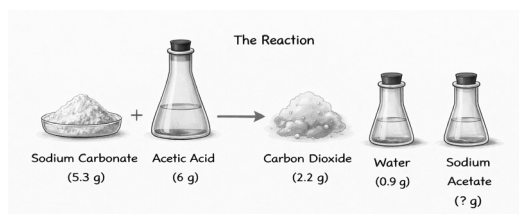
- (a) Which chemical law applies to the elemental composition of water from different sources?
- (b) What mass ratio of hydrogen to oxygen will the chemists find in both the asteroid water and the ocean water?

- (c) If a scientist decomposes 36 grams of pure water from the asteroid sample, what exact masses of hydrogen and oxygen gases will be obtained?

Ans :

- (a) The Law of Constant Proportions, also known as the Law of Definite Proportions or Proust's Law, applies here.
- (b) The chemists will find a fixed mass ratio of 1:8 for hydrogen and oxygen in both water samples, regardless of their source.
- (c) Since the ratio of hydrogen to oxygen by mass is 1:8, 9 grams of water contains 1 gram of hydrogen and 8 grams of oxygen. Therefore, 36 grams of water (which is 9×4) will yield 4 grams of hydrogen and 32 grams of oxygen.

165. In a reaction, 5.3 g of sodium carbonate reacted with 6 g of acetic acid. The products were 2.2 g of carbon dioxide, 0.9 g of water, and a certain amount of sodium acetate.



- What is the total mass of the reactants (sodium carbonate and acetic acid)?
- If the law of conservation of mass holds true for this reaction, what should be the total mass of the products (carbon dioxide, water, and sodium acetate)?
- Calculate the mass of sodium acetate formed in this reaction.
- Which postulate of Dalton's atomic theory supports the law of conservation of mass?

Ans :

- Total mass of reactants

$$= \text{Mass of sodium carbonate} + \text{Mass of acetic acid}$$

$$= 5.3 \text{ g} + 6 \text{ g}$$

$$= 11.3 \text{ g.}$$
- If the law of conservation of mass holds true, the total mass of the products should also be 11.3 g.

- Total mass of products

$$= \text{Mass of carbon dioxide} + \text{Mass of water} + \text{Mass of sodium acetate}$$

$$11.3 \text{ g} = 2.2 \text{ g} + 0.9 \text{ g} + \text{Mass of sodium acetate}$$

$$11.3 \text{ g} = 3.1 \text{ g} + \text{Mass of sodium acetate}$$

$$\text{Mass of sodium acetate} = 11.3 \text{ g} - 3.1 \text{ g} = 8.2 \text{ g.}$$

- Dalton's postulate that "Atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction" supports the law of conservation of mass.

166. In a chemistry workshop, a teacher brings a large box of building blocks of different colours and sizes. She gives each student a set of two red blocks joined together and two single white blocks. She asks them to pull the red blocks apart and attach one white block to each red block. She explains that the blocks represent tiny particles that make up all matter. Just as the students cannot break the solid plastic blocks themselves, these fundamental particles cannot be broken into smaller pieces during ordinary chemical changes; they merely rearrange to form new combinations.

QUESTIONS:

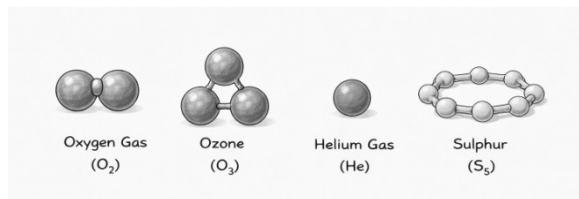
- What do the individual building blocks represent in the context of this chapter?
- Which specific postulate of Dalton's Atomic Theory states that atoms cannot be broken down during a chemical reaction?
- According to Dalton's theory, how do the atoms of a specific element (represented by the identical red blocks) compare to each other?
- If the white blocks and red blocks form a compound, what does Dalton's theory say about the ratio in which they combine?

Ans :

- The individual building blocks represent atoms, the tiny particles that make up all matter and participate in chemical reactions.
- The postulate states that atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction.
- According to Dalton, atoms of a given element are identical in mass and chemical properties. Therefore, all red block atoms are exactly the same as each other.

- (d) Dalton's theory states that atoms combine in the ratio of simple whole numbers to form compounds. The relative number and kinds of atoms are constant in a given compound.

167. Oxygen gas exists as diatomic molecules (O_2), while ozone exists as triatomic molecules (O_3). Helium (He) gas, on the other hand, exists as monoatomic particles. Sulphur can exist as polyatomic molecules, such as S_8 .



1. What is meant by the atomicity of an element?
2. What is the atomicity of oxygen in oxygen gas? What is the atomicity of oxygen in ozone?
3. Give an example of a monoatomic element mentioned in the case.
4. Why do atoms of most elements not exist independently but form molecules or ions?

Ans :

1. The atomicity of an element is the number of atoms constituting a molecule of that element.
 2. The atomicity of oxygen in oxygen gas (O_2) is 2 (diatomic). The atomicity of oxygen in ozone (O_3) is 3 (triatomic).
 3. Helium (He) is an example of a monoatomic element mentioned.
 4. Atoms of most elements are not stable enough to exist independently. They combine to form molecules or ions to achieve a more stable electron configuration (often by completing their outermost electron shell)
168. Maya, a scuba diver, is filling her air tanks for a deep-sea dive. She knows the tank contains a mixture of nitrogen and oxygen gases. While studying her diving manual, she reads that oxygen gas does not exist as single oxygen atoms floating around independently. Instead, because an oxygen atom has six electrons in its outermost shell, it always seeks out another oxygen atom. The two atoms come close together and share their electrons to achieve a stable electronic state, acting like a team to survive in nature.

QUESTIONS:

- (a) How many more electrons does a single oxygen atom need to complete its octet and become stable?
- (b) Name the type of chemical bond formed between the two oxygen atoms in Maya's tank.
- (c) How many pairs of electrons are shared between the two oxygen atoms, and what kind of bond does this represent?

Ans :

- (a) A single oxygen atom has six valence electrons, so it needs two more electrons to complete its octet (reach eight electrons) and become stable.
- (b) The bond formed is a covalent bond, which is created by the sharing of electrons between atoms.
- (c) The two oxygen atoms share two pairs of electrons. This type of interaction, holding the atoms together, represents a double bond, depicted as $O=O$.

169. An industrial factory uses various chemicals to manufacture agricultural pesticides. One day, a safety inspector reviews the inventory list of gases stored in large pressurized tanks. The labels on the tanks read PCl_3 , CS_2 , and SF_6 . The inspector notes that these compounds are formed by non-metals sharing electrons rather than transferring them. To ensure the workers understand the hazards, the inspector updates the safety manual by writing down the full chemical names of these formulas using the standard prefix system for such compounds.

QUESTIONS:

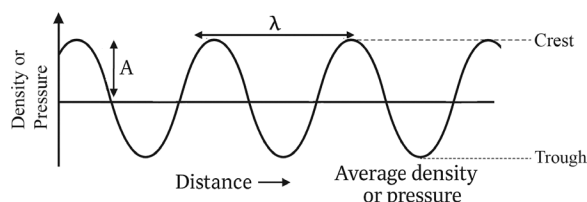
- (a) Are the compounds listed in the factory inventory ionic or covalent?
- (b) What is the general rule for modifying the name of the second element when naming these types of binary compounds?
- (c) Write the correct chemical name for PCl_3 .
- (d) Write the correct chemical name for CS_2 .
- (e) How does the prefix in SF_6 indicate the number of atoms of the second element?

Ans :

- (a) The compounds are covalent, as they are formed by non-metals sharing electrons.

4. PROPAGATION OF SOUND THROUGH AIR

Propagation of sound can be visualized as propagation of density (or pressure) variations in air medium in the form of longitudinal wave. A sound wave in graphical form is shown below in which distance from the sound source is taken along X -axis and density (or pressure) of the medium at a given time is taken along Y -axis.



5. CHARACTERISTICS OF SOUND WAVE

Important characteristics of sound waves are as follows :

5.1 Amplitude (A)

It is the magnitude of maximum disturbance (pressure or density) in the medium on either side of the mean value. Its SI unit is metre (m).

5.2 Wavelength (λ)

It is the distance between two successive compressions or two successive rarefactions. Its SI unit is metre (m).

5.3 Frequency (ν)

The number of vibrations completed per unit time by the sound is called frequency of a sound wave. Frequency of a sound wave is the number of compressions or rarefactions crossing a particular section of medium per unit time. It is denoted by ν (nu) and its SI unit is hertz (Hz), where 1 Hz = 1 vibration per second.

5.4 Time Period

The time taken between two consecutive compressions or rarefactions crossing a point is called the time period of a sound wave. Time period is denoted by T and its SI unit is second. Time period and frequency are reciprocal of each other.

$$\nu = \frac{1}{T} \text{ or } T = \frac{1}{\nu}$$

6. WAVE SPEED

Wave speed in a given medium is the distance through which the wave travels in that medium in unit time. It has a constant value in a given medium. But, it changes with change in medium. The relation between wave speed, frequency and wavelength of a wave in a given medium is shown as follows:

$$\text{Wave speed } (v) = \text{Wavelength } (\lambda) \times \text{frequency } (\nu)$$

Above relation shows that in a given medium, the wavelength is inversely proportional to the frequency of wave. So, higher is the frequency, lower is the wavelength or vice versa.

Speed of sound is much less than the speed of light. Since the speed of sound in air at 0°C is 331 ms^{-1} and speed of light is $3 \times 10^8\text{ ms}^{-1}$; hence, the sound of a thunder is heard later than the flash of lightning is seen. In a material medium, the speed of sound depends on its density and elasticity, but does not depend on its frequency, wavelength and amplitude.

The speed of sound is the least in gases, more in liquids and the highest in solids, e.g., at 25°C temperature, the speed of sound in air is 346 ms^{-1} ; in water, its value is 1498 ms^{-1} and in iron, its value is 5950 ms^{-1} . The speed of sound increases with an increase in temperature.

7. TONE AND NOTE

Tone is a sound of single frequency. Note is a sound produced on account of a mixture of several frequencies.

8. PROPAGATION OF SOUND IN DIFFERENT MEDIA

The propagation of sound refers to the way sound waves travel through different materials such as solids, liquids, and gases. Sound is a mechanical wave, which means it needs a medium made of particles to move. It travels through compressions and rarefactions created by vibrating particles.

8.1 Sound Propagation in Solids

In solids, sound travels the fastest because the particles are very closely packed and strongly connected. Vibrations are quickly passed from one particle to another. For example, sound moves much faster in iron than in air.

172. During an auto repair class, an instructor is teaching students how to clean different engine parts. He demonstrates that a solid lump of grease, which behaves like a covalent compound, will not wash away with water but dissolves easily when soaked in petrol. Later, he shows them a battery terminal encrusted with solid copper sulfate. He asks a student to test if the solid crust conducts electricity using a battery and bulb. When the bulb does not light up, he drops the crust into a beaker of water, where it dissolves, and the bulb suddenly shines brightly.

QUESTIONS:

- Based on the instructor's demonstration, how does the solubility of covalent compounds generally differ from ionic compounds in water?
- Why did the solid copper sulfate fail to conduct electricity when tested by the student?
- Why did the bulb light up when the copper sulfate was dissolved in water?
- Name another common solvent mentioned in the chapter where covalent compounds might dissolve.
- If the instructor melted the solid copper sulfate to a liquid state instead of dissolving it, would it conduct electricity? Justify your answer.

Ans :

- Ionic compounds are generally soluble in water, whereas most covalent compounds are insoluble in water but dissolve in solvents like petrol or kerosene.
- Solid copper sulfate is an ionic compound. In the solid state, its ions are held in fixed positions by strong electrostatic forces, so they cannot move freely to conduct electricity.
- When dissolved in water, the strong forces holding the copper sulfate ions together are overcome. The ions become free to move in the solution, allowing them to conduct electricity and light the bulb.
- Kerosene is another common solvent in which covalent compounds generally dissolve.
- Yes, it would conduct electricity in the molten state. Melting an ionic compound provides enough heat energy to overcome the strong inter-ionic attractions, allowing the ions to move freely and conduct electricity.

173. A team of climate scientists is studying the atmosphere of an alien planet through a powerful telescope. Their spectrographs detect large concentrations of methane and nitric acid vapors in the planet's upper clouds. To model how these gases trap heat, the scientists need to input the molecular mass of each gas into their computer simulation. They know the chemical formula for methane is CH_4 and nitric acid is HNO_3 . They pull out a periodic table to check the atomic masses: Carbon is 12 u, Hydrogen is 1 u, Nitrogen is 14 u, and Oxygen is 16 u.

QUESTIONS:

- Define molecular mass.
- Calculate the molecular mass of methane (CH_4) for the scientists' simulation.
- Calculate the molecular mass of nitric acid (HNO_3).
- Why is the term molecular mass used for methane and nitric acid instead of formula unit mass?

Ans :

- Molecular mass is the total mass of a molecule, calculated by adding the atomic masses of all the atoms present in that molecule.
- The molecular mass of methane (CH_4) is calculated as: (1 atom of C $\times$ 12 u) + (4 atoms of H $\times$ 1 u) = 12 u + 4 u = 16 u.
- The molecular mass of nitric acid (HNO_3) is calculated as: (1 atom of H $\times$ 1 u) + (1 atom of N $\times$ 14 u) + (3 atoms of O $\times$ 16 u) = 1 u + 14 u + 48 u = 63 u.
- The term molecular mass is used because methane and nitric acid are covalent compounds that exist as discrete molecules. Formula unit mass is reserved for ionic compounds, which form 3-D crystal lattices instead of independent molecules.

174. An agricultural inspector is visiting a large farm to check the quality of fertilizers being used. The farmer shows him two huge sacks. The first sack contains potassium chloride, a great source of potassium. The second sack contains sodium sulfate, which provides sulfur to the soil. The inspector decides to calculate the formula unit mass of these chemicals to help the farmer understand the concentration of nutrients per unit. He notes the atomic masses from his handbook: Potassium is 39 u, Chlorine is 35.5 u, Sodium is 23 u, Sulfur is 32 u, and Oxygen is 16 u.

QUESTIONS:

- (a) Write the chemical formulas for potassium chloride and sodium sulfate based on the valencies of their ions.
- (b) What is meant by the term formula unit mass?
- (c) Calculate the formula unit mass of potassium chloride.
- (d) Calculate the formula unit mass of sodium sulfate.

Ans :

- (a) The chemical formula for potassium chloride is KCl (K has a valency of 1, Cl has a valency of 1). The formula for sodium sulfate is Na_2SO_4 (Na has a valency of 1, SO_4 has a valency of 2).
- (b) The formula unit mass of an ionic compound is the sum of the atomic masses of all the atoms present in a formula unit, which is the simplest whole-number ratio of ions in an ionic compound.
- (c) The formula unit mass of potassium chloride (KCl) is: $(1 \times 39 \text{ u}) + (1 \times 35.5 \text{ u}) = 74.5 \text{ u}$.
- (d) The formula unit mass of sodium sulfate (Na_2SO_4) is: $(2 \times 23 \text{ u}) + (1 \times 32 \text{ u}) + (4 \times 16 \text{ u}) = 46 \text{ u} + 32 \text{ u} + 64 \text{ u} = 142 \text{ u}$.

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CHAPTER 10

Sound Waves: Characteristics and Applications

SUMMARY

1. SOUND

A form of energy which produces a sensation of hearing in our ears is called sound. In fact, when an object vibrates, its mechanical energy is transformed into sound energy. The sound of the human voice is produced on account of vibrations in vocal cords in the throat. Thus, it is clear that sound is accompanied with vibrations of an object.

2. PROPAGATION OF SOUND

The sound, produced by vibrating objects, moves through a material medium from the point of generation to the listener's ear. Sound may be propagated through a solid or a liquid or a gas. Sound energy cannot travel through vacuum.

3. WAVE

It is a disturbance which moves through a medium so that particles of the medium set neighbouring particles into motion. As a result, they produce similar motion in others and so on. Since medium particles do not move forward themselves, the disturbance is carried forward.

Alternatively, a wave is a disturbance which propagates through a medium because of the repeated to and fro vibratory motion of medium particles about their respective mean positions. It transfers both energy and momentum, but does not transfer mass.

3.1 Wave Motion

It is motion of energy (or disturbance) through a medium in the form of a wave. In a wave motion, the medium particles vibrate to and fro periodically about their respective equilibrium

positions and at the same time, they transfer energy (or disturbance) to the neighbouring particles. As a result, energy (or disturbance) spreads throughout the medium but mass (or matter) as a whole does not transfer.

3.2 Types of Waves

Waves are of three types which are as follows :

1. mechanical waves,
2. electromagnetic waves, and
3. matter waves.

Types of Mechanical Waves

They are of two types, namely

- (a) longitudinal waves, and
- (b) transverse waves.

(a) Longitudinal Waves

The waves in which medium particles vibrate back and forth about their respective mean positions along a straight line parallel to the direction of wave propagation is called longitudinal waves. In these waves, alternate regions of compression and rarefaction are formed in the medium. These waves can be formed in any media whether solid, liquid or gas, e.g., sound waves and vibrations of air columns.

(b) Transverse Waves

The waves in which medium particles vibrate to and fro about their respective mean positions perpendicular to the direction of wave propagation is called transverse waves. In these waves, alternate crests and troughs are formed in the medium. These waves can be formed in solids and on liquid surfaces only, e.g., water ripples and waves on strings.

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of loudness for a normal person. The loudness level in our classroom is about 60 decibels that correspond to an intensity level of 10^{-6} Wm^{-2} .

10. LAWS OF REFLECTION OF SOUND WAVES

Sound waves can be reflected like light. Their two laws are as follows:

- The incident and reflected sound beams and normal to the reflecting surface at the point of incidence lie in same plane.
- The angle of incidence is equal to the angle of reflection and the two lie on opposite sides of the normal. Sound waves can be reflected from any large surface, whether polished or opaque. But, reflection of sound is more pronounced if the reflecting surface is hard and smooth.

11. ECHO

It is the repetition of a sound on account of reflection of original sound from a suitable reflecting surface. If d is the distance between a person and the reflecting surface, then the person will hear an echo after a time $t = \frac{2d}{v}$,

where v = Speed of sound in air.

The time of echo must be lagging original sound by at least 0.1 s or more for a distinct echo. This is possible when the distance of reflecting surface from the source of sound is at least 17 m or more. As a result, echo is not heard in a small-sized room.

12. REVERBERATION OF SOUND

It is the phenomenon of persistence of sound in a hall or an auditorium because of repeated reflections of sound from its walls, ceiling and floor.

12.1 Reverberation Time

It is the time interval, for which the original sound persists in a hall after its production. Excessive reverberation is undesirable because it interferes with the original sound. To minimise reverberation time, we must increase absorption of sound by having a rough plaster on walls of the hall, by fitting panels of sound absorbing materials on walls and ceiling, putting on heavy carpets on floor and heavy curtains on doors and windows of the hall.

13. MULTIPLE REFLECTIONS OF SOUND

The repetitions of a sound a number of times are possible because of multiple reflections of sounds. Megaphone, stethoscope, sound board, etc., are few devices that make use of the multiple reflection of sounds waves.

14. AUDIBLE FREQUENCY RANGE

When the vibrational frequencies of human sensitive ears range from 20 Hz to 20 kHz, then this frequency range is called the audible frequency range.

15. INFRASOUNDS

Sound waves of frequencies below 20 Hz are called infrasonic sounds or infra-sounds. Animals like elephants, rhinoceroses and whales produce infrasonic sounds. Low-frequency infra-sounds are produced before the main shock waves of an earthquake are felt.

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16. ULTRASOUNDS

Sound waves of frequencies higher than 20 kHz are called ultrasonic waves or ultrasounds. Piezoelectric generator and magnetostriction oscillators are used to produce ultrasounds in a laboratory. Animals like dolphins, bats and porpoises produce ultrasounds. These animals are able to detect ultrasonic waves. Moths of certain families are very sensitive to ultrasounds. Rats also play games by producing ultrasounds.

Ultrasounds, having high frequencies, are highly energetic and travel along well-defined paths in the presence of obstacles. Thus, they are used in industries, as medical diagnostic tools, for treatment of certain medical problems and for underwater communications. Their few important applications are given below:

16.1 Applications of Ultrasounds

The application of the ultrasounds are as follows :

- Ultrasonic cleaning technique cleans a spiral tube and electronic components. Ultrasounds detect cracks and flaws in metal blocks and forgings.
- Echocardiography technique applying ultrasounds is employed to get a precise idea about the function of human heart.

8.2 Sound Propagation in Liquids

In liquids, sound travels slower than in solids but faster than in gases. The particles are moderately spaced, allowing vibrations to pass effectively. For example, sound travels faster in water than in air.

8.3 Sound Propagation in Gases

In gases, sound travels the slowest because the particles are far apart and weakly connected. Sound moves through compressions and rarefactions. For example, in air, sound travels at about 343 meters per second at room temperature.

8.4 Propagation of Sound in Vacuum

In a vacuum, sound cannot travel because there are no particles to carry vibrations. This is why there is no sound in space.

9. MUSICAL SOUND AND NOISE

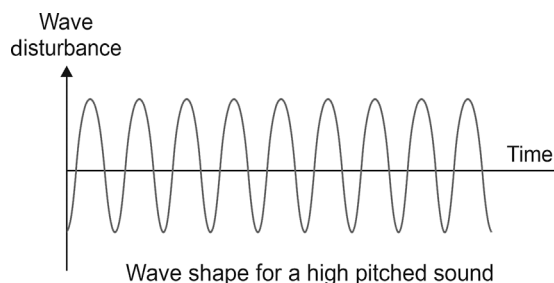
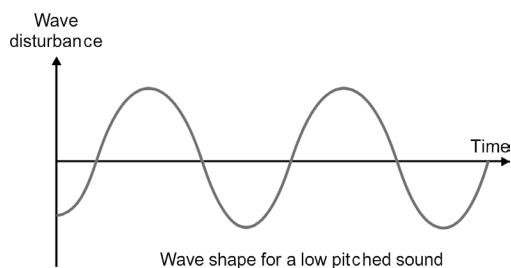
Musical sound is the sound of a note which is pleasant to listen. Noise is the sound of a note which is unpleasant to listen. A musical sound is characterised by

- (a) pitch,
- (b) loudness, and
- (c) quality.

These characteristics are subjective in nature.

9.1 Pitch

It is that characteristic of musical sound, due to which, we are able to distinguish between a shrill (high-pitched) and a hoarse (low-pitched) sound.

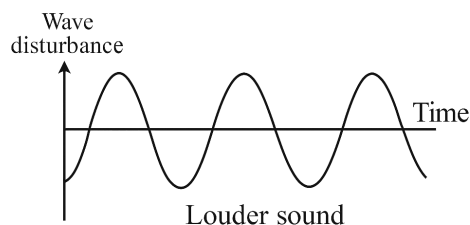
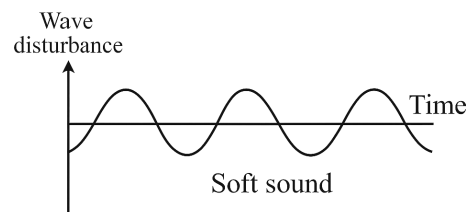


Pitch of a sound depends upon its frequency. So, higher the frequency of a sound, higher is its pitch and shriller is the sound.

9.2 Loudness

It is that characteristic of a musical sound, due to which, we are able to distinguish between a loud and a soft sound.

It depends upon the amplitude of sound. So, higher the amplitude, louder is the sound.



A sound wave spreads out from its source in all directions. Since the wave moves away from the source, its amplitude and thus, the loudness decreases.

9.3 Quality or Timbre

It is that characteristic of sound which enables us to distinguish between the sounds produced by different persons or musical instruments though the sounds may have same pitch and loudness. The sound produced by a person or a musical instrument comprises a basic fundamental frequency and different overtones of it. Because of the presence of these overtones, the sound produced by an instrument or a person is quite complex and is a characteristic of that instrument or person.

9.4 Intensity of Sound

Intensity of sound at a place is the amount of sound energy passing per unit time per unit surface area at that place. Its SI unit is Wm^{-2} . It is an objective physical quantity and it governs the loudness. But, the loudness is a subjective quantity and it is a measure of the response of the ear to a given sound. The intensity level of 10^{-12} Wm^{-2} corresponds to zero decibel level

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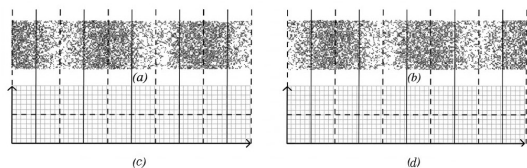
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Ans :

For figures (a) and (b), the dark, densely clustered dot regions should be labelled 'C' (compression), and the lighter, sparsely dotted regions should be labelled 'R' (rarefaction). For the graphs (c) and (d), the horizontal axis should be labelled "Distance" and the vertical axis "Density", with the dashed middle line representing "Average density". Curve (c) should be drawn as a continuous wave where crests align directly beneath the 'C' regions and troughs beneath the 'R' regions of figure (a). Curve (d) should be drawn similarly matching figure (b), resulting in a wave with a higher frequency (more cycles packed closer together) than curve (c).

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- Conduct Activity 10.1 once again with a thick rubber band and then with a thin rubber band. Does the thin rubber band vibrate faster than the thick rubber band? If yes, how do the frequency and time period of the sound produced by the thin rubber band differ from that of the thick rubber band?

Ans :

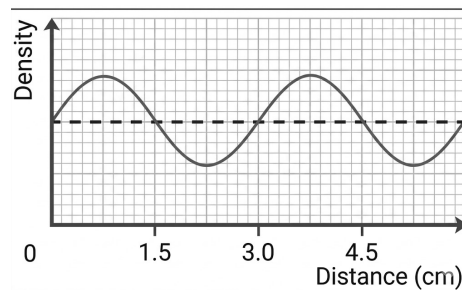
Yes, a thin rubber band will vibrate faster than a thick rubber band when plucked under similar tension. Because it vibrates faster, it completes more oscillations per second, meaning the sound produced by the thin rubber band has a higher frequency. Since the time period is inversely proportional to frequency, the time period of the sound from the thin rubber band will be shorter than that of the thick rubber band.

- If the frequency of a sound wave produced by an oscillating piston of a long tube filled with air is 20 Hz, then how many oscillations does the piston complete per minute?

Ans :

A frequency of 20 Hz means the piston completes 20 oscillations in 1 second. Therefore, in one minute (60 seconds), it will complete $20 \times 60 = 1200$ oscillations.

- For the sound wave represented by the graph shown in Figure, what is half of its wavelength?



Ans :

In the given graph, one complete wave cycle (one wavelength) spans from 0 cm to 3.0 cm on the distance axis. Therefore, the full wavelength is 3.0 cm, and half of its wavelength is 1.5 cm.

- Table shows the speed of sound in a few media at atmospheric pressure.

State	Substance/ Medium	Approximate Speed (ms ⁻¹)
Solid	Steel	5000 ms ⁻¹
Liquid	Water	1500 ms ⁻¹
Gas	Air	340 ms ⁻¹

Compare the speeds in different media by finding the ratio of

- the speed of sound in water with respect to the speed in the air.
- the speed of sound in steel with respect to the speed in the water.

Ans :

- Speed in water with respect to air

$$\frac{1500}{340} = \frac{75}{17} \approx 4.41$$

$$75 : 17 (\approx 4.4 : 1)$$

- Speed in steel with respect to water

$$\frac{5000}{1500} = \frac{10}{3} \approx 3.33$$

$$10 : 3 (\approx 3.3 : 1)$$

- Two friends are standing along a steel fence at a distance of 340 m from each other Figure. Gunjan places her ear over the fence and her friend knocks the fence with a metal object. Using the values of the speed of sound in steel and air given in Table calculate the time difference between the sound that reached Gunjan through the air and the steel. Would it have been possible for her to

3. A doctor gets image of the internal organs like liver, gall bladder, kidneys, uterus, etc., of a patient using ultrasound scanner. This technique is called ultrasonography. It is used to examine a foetus during pregnancy.
4. Ultrasounds break small stones formed in kidneys of a patient into fine grains, which are then flushed out with urine. They are used by bats to search their prey and fly in dark.

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PAUSE AND PONDER

1. Explore various ways of producing sound.

Ans :

Sound can be produced in several ways, all of which involve creating vibrations in an object. Common methods include plucking a stretched string or rubber band, striking a surface like a drum or a tuning fork, blowing air through a hollow pipe like a flute, rubbing two objects together, or vibrating vocal cords while speaking.

2. Make a list of different types of musical instruments and identify their vibrating parts which produce sound.

Ans :

1. String instruments (e.g., guitar, sitar): Stretched strings vibrate.
2. Wind instruments (e.g., flute, trumpet): The air column inside the hollow pipe vibrates.
3. Percussion instruments (e.g., tabla, drum): A stretched membrane vibrates.
4. Solid percussion (e.g., cymbals, bells): The entire solid metal body vibrates when struck.

3. **Assertion (A):** We cannot hear the sound of a bell ringing in a closed jar after most of the air is pumped out.

Reason (R): Sound requires a medium to travel.

Choose the correct statement:

- (i) Both A and R are true, but R is not the correct explanation of A.
- (ii) Both A and R are true, and R is the correct explanation of A.
- (iii) A is true, but R is false.
- (iv) A is false, but R is true.

Ans :

(ii) Both A and R are true, and R is the correct explanation of A. Sound is a mechanical wave that requires a material medium (like a gas, liquid, or solid) to propagate. When air is pumped out of the bell jar creating a vacuum, there are no particles left to transmit the vibrations from the bell to the walls of the jar and outward to our ears, hence the sound cannot be heard.

4. **Assertion (A):** Compressions and rarefactions move through the medium.

Reason (R): Individual particles of the medium continuously move forward with the wave.

Choose the correct statement:

- (i) Both A and R are true, but R is not the correct explanation of A.
- (ii) Both A and R are true, and R is the correct explanation of A.
- (iii) A is true, but R is false.
- (iv) A is false, but R is true.

Ans :

(iii) A is true, but R is false. While the disturbance in the form of compressions and rarefactions does travel forward through the medium, the individual particles of the medium do not move along with the wave. The particles merely oscillate back and forth about their mean resting positions to pass the energy along to neighboring particles.

5. When sound travels from a tuning fork to your ear, which of the following actually reaches your ear?

- (i) Air particles near the tuning fork
- (ii) Energy carried by sound waves
- (iii) The tuning fork material
- (iv) A continuous stream of compressed air

Ans :

(ii) Energy carried by sound waves. During sound propagation, particles of the medium only vibrate in place; it is the wave's energy and disturbance that travels from the source to the listener's ear.

6. The variation of density of the medium for two sound waves is shown in Figure (a) and (b). Label compression and rarefaction by C and R on it. In the graph given in Figure (c) and (d), label the axes and draw the curves corresponding to Figure (a) and (b).

- (b) When naming these compounds, the first element retains its regular name, while the second element's name ends in -ide.
- (c) The correct chemical name for PCl_3 is phosphorus trichloride.
- (d) The correct chemical name for CS_2 is carbon disulfide.
- (e) In SF_6 , the prefix hexa- is used before fluoride to indicate that there are exactly six fluorine atoms in the molecule.
170. A popular television chef is hosting an episode focused on the science of food. He holds up a block of pure, metallic sodium in a jar of oil, explaining that it is highly reactive and would explode if placed in water. He then displays a sealed flask of toxic, green chlorine gas. He tells the audience that when these two dangerous elements react, the sodium atom completely gives away its single outer electron to the chlorine atom. This dramatic exchange transforms them into harmless crystals of table salt, which he then sprinkles onto a fresh plate of fries.

QUESTIONS:

- (a) What kind of charged particle does the sodium atom become after losing its outer electron?
- (b) Why does the chlorine atom accept exactly one electron from sodium?
- (c) What is the electrostatic force of attraction holding the sodium and chloride ions together called?
- (d) The chef mentions that the resulting table salt is a crystal. Briefly describe how the ions are arranged in this crystal structure.

Ans :

- (a) After losing its one valence electron, the sodium atom becomes a positively charged species called a sodium cation, represented as Na^+ .
- (b) A chlorine atom has seven valence electrons. It accepts exactly one electron to complete its octet and achieve a stable electronic configuration, becoming a chloride anion.
- (c) The electrostatic force of attraction between oppositely charged ions that holds them together is called an ionic bond.
- (d) In the crystal structure of table salt, the oppositely charged ions are arranged in a regular, repeating three-dimensional pattern

called a crystal lattice. Each sodium ion is surrounded by six chloride ions, and each chloride ion is surrounded by six sodium ions.

171. A pharmacist in a local clinic is preparing a custom antacid powder for a patient with severe heartburn. The recipe requires mixing two specific dry ingredients: magnesium hydroxide and calcium carbonate. To properly log the preparation in the clinic's digital database, the pharmacist must enter the exact chemical formulas of these substances. She grabs her reference chart, notes the valencies of the magnesium ion (+2), the calcium ion (+2), the hydroxide ion (-1), and the carbonate ion (-2), and carefully uses the criss-cross method to write them down.

QUESTIONS:

- (a) What is a polyatomic ion? Identify one polyatomic ion used by the pharmacist.
- (b) Using the criss-cross method, determine the correct chemical formula for magnesium hydroxide.
- (c) Determine the correct chemical formula for calcium carbonate and explain why the subscript numbers do not appear in the final formula.

Ans :

- (a) A polyatomic ion is an ion formed by the combination of atoms of two or more elements that act as a single charged entity. Examples from the pharmacist's ingredients include the hydroxide ion (OH^-) and the carbonate ion (CO_3^{2-}).
- (b) For magnesium hydroxide, the symbol for magnesium is Mg with a charge of 2+, and hydroxide is OH with a charge of 1-. Criss-crossing these valencies gives the formula $\text{Mg}(\text{OH})_2$. Brackets are used because there are two polyatomic hydroxide ions.
- (c) For calcium carbonate, calcium is Ca with a charge of 2+, and carbonate is CO_3 with a charge of 2-. Criss-crossing gives $\text{Ca}_2(\text{CO}_3)_2$. Since the valencies are the same, they give the simplest ratio of 1:1. Therefore, it is simply written as CaCO_3 .

distinguish between the two sounds? (The time interval between two sounds must be at least 0.1 s to be heard separately.)



Ans :

The time taken for sound to travel through the air is

$$\begin{aligned}\text{Distance} / \text{Speed} &= 340 \text{ m} / 340 \text{ ms}^{-1} \\ &= 1 \text{ second.}\end{aligned}$$

The time taken through the steel fence is $340 \text{ m} / 5000 \text{ ms}^{-1} = 0.068 \text{ seconds}$.

The time difference is $1 \text{ s} - 0.068 \text{ s} = 0.932 \text{ seconds}$. Since this time difference (0.932 s) is much greater than the 0.1 s threshold required by the human ear, it would be easily possible for her to distinguish between the two sounds, hearing the knock through the steel first.

- 12.** An experiment is being set up that requires echoes to arrive at least 0.2 s after the emission of sound. What minimum distance should a reflecting surface be placed at? Assume the speed of sound to be 343 ms^{-1} .

Ans :

The total distance the sound must travel (to the surface and back) to take 0.2 seconds is

$$\begin{aligned}\text{Distance} &= \text{Speed} \times \text{Time} \\ &= 343 \text{ ms}^{-1} \times 0.2 \text{ s} \\ &= 68.6 \text{ m.}\end{aligned}$$

Because this is a round trip, the reflecting surface should be placed at a minimum distance of half that total, which is $68.6 \text{ m} / 2 = 34.3 \text{ meters}$.

- 13.** Sound travels much farther in water than light, and thus, is used for various underwater applications. A sonar signal sent to find the depth of ocean takes 4 s to return. What is the depth of the ocean at that location if the speed of sound in seawater is 1500 ms^{-1} ?

Ans :

The sonar signal takes 4 seconds for the total round trip, meaning it takes 2 seconds to reach the ocean floor.

$$\begin{aligned}\text{Depth} &= \text{Speed} \times \text{Time}, \\ &= 1500 \text{ ms}^{-1} \times 2 \text{ s} = 3000 \text{ meters.}\end{aligned}$$

NCERT EXERCISE

- 1.** Which observation best supports the idea that sound is a mechanical wave?
- Sound shows reflection
 - Sound needs a medium to propagate
 - Sound has frequency
 - Sound carries energy

Ans :

Option (ii) is the correct answer. A mechanical wave is explicitly defined as a wave that requires a material medium (like a solid, liquid, or gas) for its propagation. The observation that sound cannot travel through a vacuum and needs a medium directly confirms its mechanical nature.

- 2.** For a sound wave propagating in a medium, increasing its frequency will increase its
- wavelength
 - speed
 - number of compressions per second
 - time period

Ans :

Option (iii) is the correct answer. Frequency is defined as the number of complete oscillations or density variations per unit time. Therefore, an increase in frequency directly means an increase in the number of compressions (and rarefactions) passing a fixed point every second.

- 3.** If 20 compressions pass a point in 4 seconds, the frequency is
- 80 Hz
 - 5 Hz
 - 10 Hz
 - 0.2 Hz

Ans :

Option (ii) is the correct answer. Frequency is calculated as the total number of oscillations divided by the time taken. 20 compressions passing in 4 seconds means the frequency is

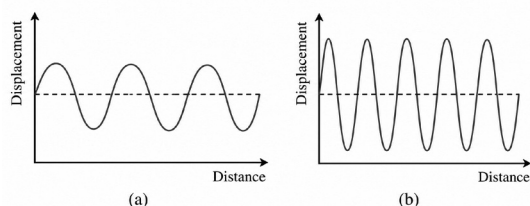
$$= 20 / 4 = 5 \text{ Hz.}$$

4. In a room, the reflected sound reaches the ear 0.05 s after its production. Will it produce an echo or reverberation? Justify your answer.

Ans :

It will produce reverberation. For the human brain to perceive a reflected sound as a distinct echo, the time gap between the original sound and the reflection must be at least 0.1 seconds. Since the reflected sound in this case arrives in 0.05 seconds (which is less than 0.1 seconds), the sounds will blend together, causing the sound to persist as reverberation.

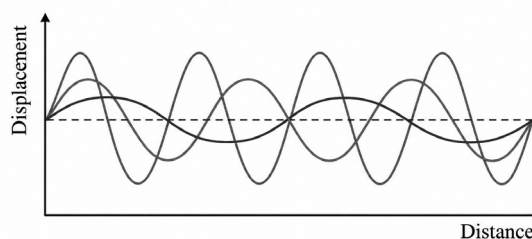
5. Graphs representing two sound waves are given in Figure. If the scales on the X and Y axes of the two graphs are the same, which of the two sound waves has (i) greater wavelength, and (ii) smaller amplitude?



- (i) Which of the two sound waves has greater wavelength?
 (ii) Which of the two sound waves has smaller amplitude?

Ans :

- (i) Sound wave (a) has a greater wavelength. Wavelength is the distance between two consecutive crests, and observing the graphs, the physical distance between the crests is clearly larger in graph (a) than in graph (b).
 (ii) Sound wave (a) has a smaller amplitude. Amplitude is represented by the maximum height of the wave from the average density line. The peaks in graph (a) are visibly shorter than the peaks in graph (b).
 6. The sound waves emitted by three sources A, B and C are represented in Figure. If the frequency of A is maximum and C is minimum, identify the corresponding curves, and mark A, B and C on them.



Ans :

In a density-distance graph, a higher frequency corresponds to more cycles packed into the same distance.

- Curve A corresponds to the green wave, which has the most densely packed cycles (shortest wavelength), indicating the maximum frequency.
- Curve B corresponds to the red wave, which has an intermediate number of cycles, indicating a frequency between the maximum and minimum.
- Curve C corresponds to the blue wave, which has the fewest cycles spread over the distance (longest wavelength), indicating the minimum frequency.

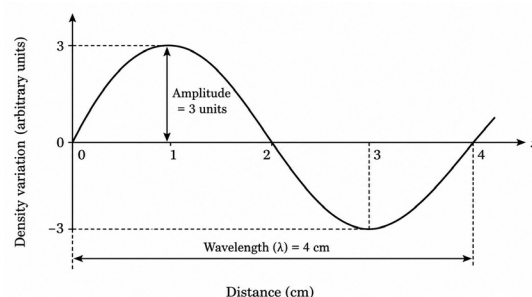
To mark them on the graph, you would write 'A' next to the green wave, 'B' next to the red wave, and 'C' next to the blue wave.

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Draw a graph to represent a sound wave for which the density amplitude is 3 units and wavelength is 4 cm.

Ans :



8. In a movie, while showing the explosion of a spacecraft in space, a flash of light is shown along with sound at the same time. What are the errors in this depiction?

Ans :

There are two major scientific errors in this depiction. First, outer space is a near vacuum, and because sound is a mechanical wave that requires a material medium to propagate, the explosion would not produce any sound that could travel to an observer. Second, even if a medium were present, light travels much faster (300,000 km/s) than sound; therefore, a distant observer would see the flash of light well before hearing the sound, not simultaneously.

9. A source produces a sound wave of wavelength 3.44 m. If the wave travels with a speed of 344 ms⁻¹ find its time period.

Ans :

Given:

$$\text{Wavelength } (\lambda) = 3.44 \text{ m}$$

$$\text{Speed of sound } (v) = 344 \text{ m/s}$$

$$\text{We know that: } v = f \times \lambda$$

$$\text{So, frequency: } f = \frac{v}{\lambda} = \frac{344}{3.44} = 100 \text{ Hz}$$

Now, time period is the reciprocal of frequency:

$$T = \frac{1}{f} = \frac{1}{100}$$

$$T = 0.01 \text{ s}$$

The time period of the sound wave is 0.01 seconds.

10. A ship searching for a sunken ship sent a sonar signal and detected an echo after 5 s. If ultrasonic wave travels at 1525 ms⁻¹ in seawater, approximately how far down in the ocean is the wreckage of the sunken ship located?

Ans :

The total time of 5 seconds is for the sonar signal to travel down to the wreckage and reflect back up to the ship. Therefore, the time taken to just reach the wreckage is half of this, which is $5 / 2 = 2.5$ seconds.

$$\begin{aligned} \text{Distance} &= \text{Speed} \times \text{Time}, \\ &= 1525 \text{ m/s} \times 2.5 \text{ s} \\ &= 3812.5 \text{ meters.} \end{aligned}$$

The sunken ship is located approximately 3812.5 metres below the ocean surface.

11. A vehicle is fitted with an ultrasonic distance sensor as part of parking assistance system which provides echolocation, while the driver is reversing the vehicle. It emits ultrasonic wave (about 40 kHz) which is reflected by the obstacle. When the warning beep starts sounding at a distance of 1.2 m from the obstacle, how much time is taken by ultrasonic wave to travel to the obstacle and come back? Assume the speed of ultrasonic wave in air to be 345 ms⁻¹.

Ans :

The total distance the ultrasonic wave must travel is twice the distance to the obstacle (from the vehicle to the obstacle and back), which is $2 \times 1.2 \text{ m} = 2.4 \text{ m}$.

Now, using the formula:

$$\begin{aligned} \text{Time} &= \text{Total Distance} / \text{Speed}. \\ &= 2.4 \text{ m} / 345 \text{ m/s}, \\ &= 0.00696 \text{ seconds} \\ &= 0.007 \text{ s (approximately)} \end{aligned}$$

12. The speed of sound in air is about 331 ms⁻¹ at 0 °C and nearly 344 ms⁻¹ at 22 °C. Roughly how much extra time will the sound of thunder take to travel a distance of 1720 m, if the air temperature changes from 22 °C to 0 °C? Assume that all other conditions remain unchanged.

Ans :

Given:

$$\text{Speed of sound at } 22^\circ\text{C } (v_1) = 344 \text{ m/s}$$

$$\text{Speed of sound at } 0^\circ\text{C } (v_2) = 331 \text{ m/s}$$

$$\text{Distance } (d) = 1720 \text{ m}$$

Time taken at 22°C:

$$\begin{aligned} t_1 &= \frac{d}{v_1} \\ &= \frac{1720}{344} = 5 \text{ s} \end{aligned}$$

Time taken at 0°C:

$$\begin{aligned} t_2 &= \frac{d}{v_2} \\ &= \frac{1720}{331} = 5.196 \text{ s} \end{aligned}$$

Extra time taken when temperature drops from 22°C to 0°C:

$$\begin{aligned} \Delta t &= t_2 - t_1 \\ &= 5.196 - 5 \\ \Delta t &\approx 0.196 \text{ s} \end{aligned}$$

14. Consider the following statements regarding the regions formed during the propagation of a sound wave in a gas:
1. Compressions are regions of high air density.
 2. Rarefactions are regions where particles are crowded together.
 3. Rarefactions represent areas of low air pressure.
 4. Compressions are regions where the volume momentarily increases.

Which of the statements given above are correct?

- (A) 1 and 3 only
 (B) 2 and 4 only
 (C) 1, 2, and 3 only
 (D) 1, 3, and 4 only

Ans : (A)

As sound travels, it creates alternating pressure zones. Compressions are specific regions where the particles are forced closely together, resulting in high density and pressure. Conversely, rarefactions are regions where the particles are spread further apart, leading directly to comparatively lower density and significantly reduced atmospheric pressure in that area.

15. Accurately match the fundamental physical characteristics of a sound wave listed in List-I with their officially recognized standard SI units presented in List-II.

	List-I (Wave Characteristic)		List-II (SI Unit)
P.	Wavelength	1.	Hertz (Hz)
Q.	Frequency	2.	Meter (m)
R.	Time period	3.	Meter per second (m/s)
S.	Speed of sound	4.	Second (s)

- (A) P-2, Q-1, R-4, S-3
 (B) P-1, Q-2, R-3, S-4
 (C) P-2, Q-4, R-1, S-3
 (D) P-3, Q-1, R-4, S-2

Ans : (A)

In standard scientific measurement, wavelength is a physical distance and is logically measured in meters (m). Frequency measures cycles per second, designated as Hertz (Hz). Time period is a duration strictly measured in seconds (s). Finally, speed measures distance over time, officially quantified as meters per second (m/s).

16. Which distinct characteristic properly differentiates a longitudinal wave from a transverse wave?
- (A) A longitudinal wave transfers energy, whereas a transverse wave transfers matter.
 (B) Longitudinal wave particles vibrate parallel to propagation, while transverse wave particles vibrate perpendicularly.
 (C) A longitudinal wave can travel through a vacuum, but a transverse wave strictly cannot.
 (D) Longitudinal waves possess frequency, whereas transverse waves only possess amplitude.

Ans : (B)

The fundamental distinction lies purely in the direction of particle oscillation relative to the wave's movement. In longitudinal waves like sound, medium particles vibrate parallel to the direction of propagation. In transverse waves, such as light or waves on a string, particles oscillate perpendicularly to the advancing wave direction.

17. An educator uses a long, flexible metal slinky toy to accurately model sound propagation. Pushing and pulling one end of the slinky in quick succession successfully creates which of the following wave patterns?
- (A) Only high-density transverse crests moving forward continuously.
 (B) Alternating regions of clustered turns and spread-out turns travelling forward.
 (C) A steady, unbroken stream of metallic coils moving straight to the other end.
 (D) Circular ripples expanding perpendicularly from the source of the initial disturbance.

Ans : (B)

A stretched slinky provides an excellent visual analogy for longitudinal sound waves. Pushing and pulling the slinky's end generates compressions, where the metal coils are clustered tightly together, and rarefactions, where the coils are spread far apart. These alternating disturbances travel linearly along the spring without moving the entire slinky.

18. **Assertion (A):** All sound waves are strictly classified as mechanical waves.

Reason (R): Sound waves do not require any physical material medium for their outward propagation.

- (A) Both A and R are true and R is the correct explanation of A

OBJECTIVE QUESTIONS

1. Which of the following conditions is primarily responsible for the production of sound in a physical object?
- The object must be stationary and placed in a vacuum.
 - The object must undergo continuous periodic chemical reactions.
 - The object must undergo a periodic to-and-fro physical motion.
 - The object must experience a rapid increase in local temperature.

Ans : (C)

Sound is fundamentally produced by vibrating objects. Vibration refers to the rapid periodic and to-and-fro motion or oscillation of an object. When a physical body vibrates, it transfers kinetic energy to the adjacent particles of the surrounding medium, thereby initiating a sound wave that propagates outward from the source.

2. **Assertion (A):** Humans produce sound through the vibration of vocal cords located in the larynx.
Reason (R): Sound is a form of mechanical energy that transfers through the physical displacement of an entire medium.
- Both A and R are true and R is the correct explanation of A
 - Both A and R are true but R is not the correct explanation of A
 - A is true but R is false
 - A is false but R is true

Ans : (C)

The assertion is entirely correct as human vocal cords, located in the larynx, vibrate to produce sound. The reason is completely false because sound propagation does not involve the physical displacement of the entire medium; rather, the particles merely oscillate about their mean positions to transfer energy forward continuously.

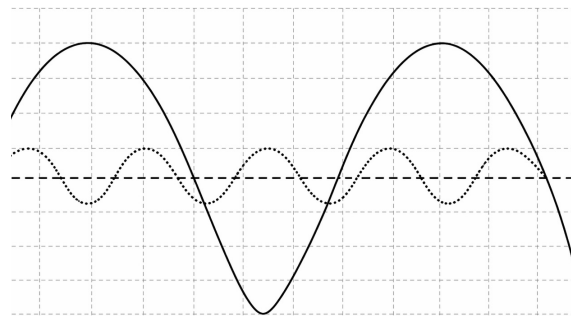
3. Consider the following statements regarding a tuning fork experiment:
- Striking a tuning fork against a soft rubber pad produces a distinct sound.
 - Touching the vibrating prong to a water surface creates visible outward waves.
 - The sound produced by the tuning fork can easily propagate through a vacuum.
- Which of the statements given above are correct?
- 1 and 2 only

- 2 and 3 only
- 1 and 3 only
- 1, 2, and 3

Ans : (A)

Striking a tuning fork makes its prongs vibrate, producing sound, and touching it to water visibly demonstrates this vibrational energy through wave formation. However, the third statement is fundamentally incorrect because sound is a mechanical wave that strictly requires a material medium and cannot propagate through a vacuum space.

4. The graph illustrates the density variation of two different sound waves travelling through the same medium. How do the physical characteristics of the sound represented by Wave P compare to those of Wave Q?



- Wave P produces a softer sound with a higher pitch than Wave Q.
- Wave P produces a louder sound with a higher pitch than Wave Q.
- Wave P produces a softer sound with a lower pitch than Wave Q.
- Wave P produces a louder sound with a lower pitch than Wave Q.

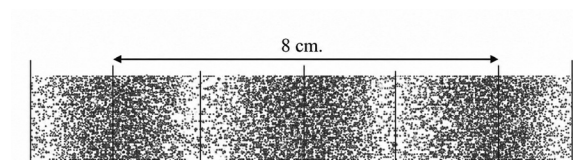
Ans : (D)

Loudness depends on amplitude, while pitch depends on frequency. Wave P has a greater maximum displacement from the average density (higher amplitude), making it louder than Wave Q. However, Wave P has a longer wavelength, which corresponds to a lower frequency. Therefore, Wave P represents a louder but lower-pitched sound.

5. In certain insect species, sound is not produced by vocal cords. Which specific mechanism do grasshoppers and crickets utilize to generate their characteristic sounds?
- By rapidly expanding and contracting their abdominal cavities.

Sound takes approximately 0.196 seconds extra to travel the same distance at 0°C compared to 22°C , since sound travels slower at lower temperatures.

13. The variation of density of medium for a sound wave propagating with a speed of 340 ms^{-1} is shown in Figure. Calculate the wavelength and frequency of the sound wave.



Ans :

From the figure, the 8 cm length shows 2 complete wavelengths.

So, wavelength:

$$\lambda = \frac{8}{2} = 4\text{ cm} = 0.04\text{ m}$$

As we know that,

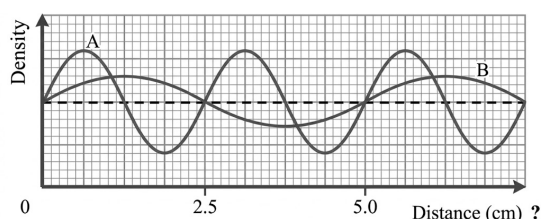
$$\text{Speed} = \text{Wavelength} \times \text{Frequency},$$

$$\text{frequency} = \text{Speed} / \text{Wavelength}.$$

$$= 340 / 0.04$$

$$= 8500\text{ Hz}.$$

14. The graphical representation of two sound waves A and B propagating at the same speed of 345 ms^{-1} is shown in Figure. What is the wavelength of each of them? Also, calculate their frequencies.



Ans :

For sound wave A (red curve), one complete cycle spans a distance of 5.0 cm on the graph. Therefore, its wavelength is 5.0 cm or 0.05 m.

$$\text{frequency} = \text{Speed} / \text{Wavelength}$$

$$= 345\text{ m/s} / 0.05\text{ m}$$

$$= 6900\text{ Hz}.$$

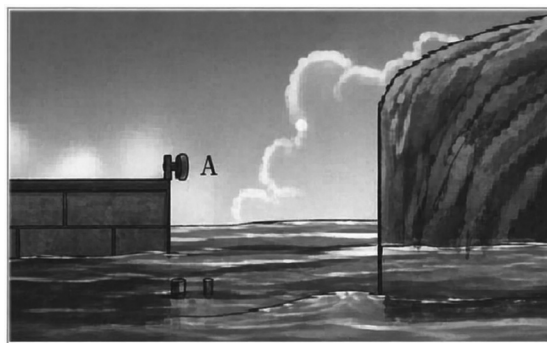
For sound wave B (blue curve), two complete cycles fit within the 5.0 cm mark, meaning one cycle spans 2.5 cm.

Therefore, its wavelength is 2.5 cm or 0.025 m.

$$\text{frequency} = 345\text{ m/s} / 0.025\text{ m}$$

$$= 13800\text{ Hz}.$$

15. Two identical sound sources are placed at A and B, one in air and one submerged in water. Both produce sounds at the same time, which travel horizontally to the vertical side of the cliff and come back. If the time taken by the sound to return to A is 4.5 times that of B, what is the ratio between the speeds of sound in air and water?



Ans :

Let the total distance traveled by both sounds to the cliff and back be D.

$$\text{The speed of sound in air } (v_A) = D/t_A,$$

$$\text{The speed of sound in water } (v_B) = D/t_B,$$

where t_A and t_B are the respective return times.

$$\text{The ratio of their speeds } v_A/v_B = t_B/t_A.$$

We are given that the time in air is 4.5 times the time in water,

$$\text{so } t_A = 4.5 \times t_B.$$

Substituting this into our ratio gives

$$v_A/v_B = t_B/(4.5 \times t_B)$$

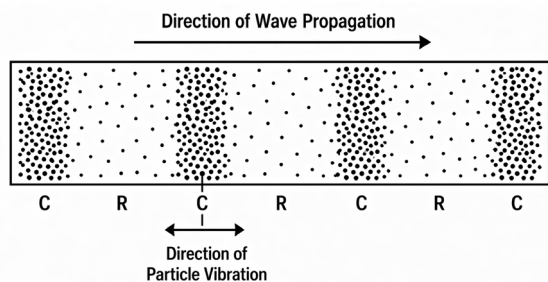
$$= 1/4.5$$

$$= 2/9$$

Therefore, the ratio between the speeds of sound in air and water is 2:9.

only the mechanical disturbance, carrying the acoustic energy, that actually propagates forward continuously through the entire transmitting material medium.

10. Based on the particle arrangement and motion indicated in the diagram, identify the regions and the nature of the wave.



- (A) C represents compression, R represents rarefaction, and it is a transverse wave.
 (B) C represents compression, R represents rarefaction, and it is a longitudinal wave.
 (C) C represents a crest, R represents a trough, and it is a transverse wave.
 (D) C represents rarefaction, R represents compression, and it is a longitudinal wave.

Ans : (B)

The diagram illustrates a longitudinal wave where particles oscillate parallel to the wave propagation. Region C shows particles closer together, representing higher density and pressure called compression. Region R shows particles spread apart, representing lower density called rarefaction. Transverse waves involve perpendicular particle vibration, unlike the horizontal motion shown here.

11. Arrange the following procedural steps of the standard vacuum bell jar experiment in their correct logical sequence.
1. Turn on the electric bell to produce a loud continuous ringing sound.
 2. Observe that the sound completely disappears despite the hammer striking.
 3. Place an electric bell securely inside an airtight glass bell jar.
 4. Gradually pump out the air from the jar using an attached vacuum pump.
- (A) 3, 1, 4, 2
 (B) 1, 3, 4, 2
 (C) 3, 4, 1, 2
 (D) 4, 3, 1, 2

Ans : (A)

The correct experimental sequence begins by placing the bell inside the jar. Next, the bell is turned on to confirm the sound travels through air. Following this, the vacuum pump is activated to gradually remove the air. Finally, the observer notes that the ringing sound entirely ceases in vacuum.

12. If an explosion occurs on the surface of the Moon, an observer stationed safely on Earth will not hear the sound. Which scientific principle best explains this occurrence?
- (A) The frequency of the explosion sound exceeds the human audible range limit.
 (B) The intense gravitational pull of the Earth deflects the sound waves away.
 (C) Sound fundamentally requires a material medium and cannot traverse the vacuum of space.
 (D) The amplitude of the sound waves decreases instantly to zero upon generation.

Ans : (C)

Sound waves are strictly classified as mechanical waves. This classification means they inherently depend on the collision of physical particles within a medium, such as solids, liquids, or gases, to propagate. Because the vast region between the Moon and Earth is a vacuum, the acoustic waves cannot travel across.

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13. What precise term is used to describe a wave wherein the individual particles of the medium vibrate back and forth parallel to the direction of wave propagation?
- (A) Electromagnetic wave
 (B) Transverse wave
 (C) Surface wave
 (D) Longitudinal wave

Ans : (D)

A longitudinal wave is formally defined as a type of wave where the particles of the transmitting medium oscillate parallel to the direction of wave propagation. Sound propagating through air behaves precisely in this manner, creating an alternating series of compressions and rarefactions as the disturbance travels continuously forward.

This standard experiment visually proves that sound carries and transfers actual physical energy. As the sound waves propagate outward through the air, the transmitted energy strikes the flexible stretched membrane, forcing it to vibrate. This induced vibration instantly transfers kinetic energy to the salt grains, causing them to jump noticeably.

23. Based on the provided data regarding the propagation of sound at 20°C, which option correctly identifies the physical state of mediums A, C, and the nature of D?

Medium	Speed of Sound (m/s)
A	5100
B	343
C	1493
D	0

- (A) A is solid, C is gas, D is liquid
 (B) A is solid, C is liquid, D is vacuum
 (C) A is liquid, C is gas, D is vacuum
 (D) A is gas, C is solid, D is liquid

Ans : (B)

Sound travels fastest in solids (A: 5100 m/s) and slower in liquids (C: 1493 m/s). It cannot travel through a vacuum (D: 0 m/s), as it requires a material medium to propagate.

Thus, A is solid, C is liquid, and D is a vacuum. Gas has the lowest non-zero speed, like medium B.

24. As a sound wave propagates outward from an initiating source through a stable material medium, which specific physical entity actually moves linearly across a large distance?
- (A) The physical particles of the medium itself.
 (B) Only the localized rarefaction particles.
 (C) The mechanical energy conveyed by the disturbance.
 (D) The isolated, highly compressed pockets of static air.

Ans : (C)

During sound wave propagation, the physical particles of the medium solely vibrate back and forth around their original equilibrium positions; they do not migrate forward. It is exclusively the mechanical disturbance, and consequently the kinetic energy it carries, that physically travels

outward across large distances from the original sound source.

25. Select the correct sequential order that accurately traces the transfer of sound energy from a human speaker directly to a listener's ear.
- (A) Air particles vibrate → Vocal cords vibrate → Eardrum vibrates → Energy propagates
 (B) Vocal cords vibrate → Air particles vibrate → Energy propagates → Eardrum vibrates
 (C) Eardrum vibrates → Energy propagates → Air particles vibrate → Vocal cords vibrate
 (D) Energy propagates → Vocal cords vibrate → Eardrum vibrates → Air particles vibrate

Ans : (B)

Sound production begins when a speaker's vocal cords vibrate. These vibrations immediately transfer kinetic energy to nearby air particles, making them oscillate. This continuous particle interaction allows the mechanical energy to propagate forward as a wave until it finally reaches and forcefully strikes the listener's eardrum, causing it to vibrate.

26. Which explicit mathematical formula accurately represents the fundamental relationship between the frequency (ν) of a sound wave and its complete time period (T)?
- (A) $\nu = T^2$
 (B) $\nu = T$
 (C) $\nu = \frac{1}{T}$
 (D) $\nu = 1 - T$

Ans : (C)

Frequency is strictly defined as the total number of complete oscillations occurring per unit time, while the time period is the total time taken to complete exactly one single oscillation. Because they represent reciprocal concepts regarding wave cycles, they are mathematically related by the straightforward inverse equation: $\nu = \frac{1}{T}$.

27. In the context of a longitudinal acoustic wave travelling continuously through a gaseous medium, what does the specific term "wavelength" technically define?
- (A) The vertical distance measured linearly from a wave crest down to a trough.
 (B) The total horizontal distance covered entirely by the sound within one full second.
 (C) The maximum spatial displacement of an individual air particle from its mean resting position.

- (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

The assertion is true because sound waves are indeed classified as mechanical waves. However, the reason provided is fundamentally false. The defining characteristic of any mechanical wave is precisely that it necessitates a physical material medium, such as a solid, liquid, or gas, to propagate energy from a source.

19. During the outward propagation of a sound wave through a gaseous medium, which critical physical parameters precisely characterize a compression zone?
- (A) Minimum air density and minimum localized atmospheric pressure.
 (B) Maximum air density and minimum localized atmospheric pressure.
 (C) Minimum air density and maximum localized atmospheric pressure.
 (D) Maximum air density and maximum localized atmospheric pressure.

Ans : (D)

A compression is inherently a localized region within a medium where the individual particles are temporarily forced close together by the passing sound energy. This localized crowding logically results in a significant, momentary increase in both the physical density of the particles and the associated internal pressure of the gas.

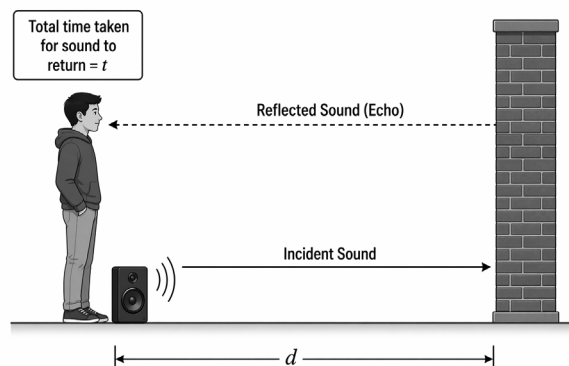
20. In the standard graphical representation of a sound wave showing medium density plotted against distance, what specific physical state does the lowest point, known as a trough, signify?
- (A) The region of absolute maximum density and highest pressure.
 (B) The region of exactly average atmospheric density and pressure.
 (C) The region of absolute minimum density and lowest pressure.
 (D) The physical location where the sound source fundamentally originated.

Ans : (C)

When graphing a sound wave's density fluctuations over distance, the curve features periodic highs and lows. The uppermost peaks, called crests, signify compressions with maximum density. In

contrast, the lowest points on the curve, called troughs, directly represent rarefactions, indicating regions where the medium's density and pressure reach their minimums.

21. A person conducts an experiment in an empty corridor. A sound is emitted, and its reflection returns to the source after time 't'. Which mathematical expression correctly calculates the speed (v) of the sound in this specific scenario?



- (A) $v = d / t$
 (B) $v = 2d / t$
 (C) $v = d / 2t$
 (D) $v = d \times t$

Ans : (B)

In an echo scenario, the sound wave must travel from the source to the reflecting surface and then back to the listener. Therefore, the total distance covered by the sound is twice the distance to the wall (2d). Speed is total distance divided by total time, making the correct mathematical relationship $v = 2d / t$.

22. A student tightly stretches a thin rubber membrane over a hollow bowl and sprinkles dry salt grains evenly on top. When a loud sound is produced nearby without touching the bowl, the grains begin to jump vigorously. What scientific principle does this practically demonstrate?
- (A) Sound naturally destroys the structural integrity of thin membranes.
 (B) Sound is a mechanical force that strictly moves particles laterally.
 (C) Sound is a form of energy that can be physically transferred.
 (D) Sound generates intense localized gravitational waves in open air.

Ans : (C)

- (B) By striking or rubbing specific body parts like wings or legs together.
- (C) By forcing compressed air rapidly through specialized respiratory tubes.
- (D) By tapping their antennae rhythmically against hard external surfaces.

Ans : (B)

Animals utilize various unique methods to communicate. Specifically, grasshoppers and crickets generate sound by continuously striking or rubbing their wings or legs against each other. This friction causes physical vibrations in their body parts, which subsequently disturb the surrounding air molecules, thereby producing the distinct chirping sounds we hear.

6. Match the specific conditions or materials in List-I with their corresponding sound propagation characteristics in List-II.

List-I (Medium Type)		List-II (Propagation Characteristic)	
P.	Solid steel	1.	Sound cannot propagate at all
Q.	Liquid water	2.	Sound travels at approximately 340 m/s
R.	Gaseous air	3.	Sound travels around 1500 m/s
S.	Outer space vacuum	4.	Sound travels at approximately 5000 m/s

- (A) P-4, Q-3, R-2, S-1
- (B) P-3, Q-4, R-2, S-1
- (C) P-4, Q-2, R-3, S-1
- (D) P-1, Q-2, R-3, S-4

Ans : (A)

Sound travels fastest through solid materials, with speeds reaching roughly 5000 meters per second in steel. In liquid water, it propagates around 1500 meters per second. In gaseous air, the speed drops to approximately 340 meters per second. In a complete vacuum, mechanical sound waves simply cannot propagate anywhere.

7. In a laboratory experiment, an electric bell is placed inside an airtight glass bell jar connected to a vacuum pump. What is the primary observation as air is gradually removed from the jar?
- (A) The pitch of the sound becomes increasingly higher.
 - (B) The sound of the bell remains unchanged in loudness.

- (C) The sound of the bell gradually becomes fainter and eventually stops.
- (D) The frequency of the bell's vibration visibly decreases to zero.

Ans : (C)

As the vacuum pump gradually extracts air from the sealed bell jar, the density of the medium decreases significantly. Consequently, the loudness of the ringing sound steadily diminishes. Once a near vacuum is achieved, the sound entirely ceases because mechanical sound waves strictly require a material medium to propagate.

8. **Assertion (A):** Astronauts performing a spacewalk cannot communicate directly by speaking to one another.

Reason (R): Sound waves are mechanical waves that require a material medium to travel, which is absent in space.

- (A) Both A and R are true and R is the correct explanation of A
- (B) Both A and R are true but R is not the correct explanation of A
- (C) A is true but R is false
- (D) A is false but R is true

Ans : (A)

Outer space is essentially a vacuum lacking any dense material medium like air or water. Since sound is a mechanical wave that fundamentally depends on interacting particles to transfer vibrational energy, it cannot travel through the emptiness of space. Therefore, astronauts must rely on special radio communication devices instead.

9. When a sound wave travels through air from a speaker to a listener, what exactly moves from the source to the receiver?
- (A) The physical air particles travel continuously across the entire distance.
 - (B) A steady stream of compressed air flows toward the listener.
 - (C) Only the disturbance and transferred energy move through the medium.
 - (D) Both the air particles and the acoustic energy travel together simultaneously.

Ans : (C)

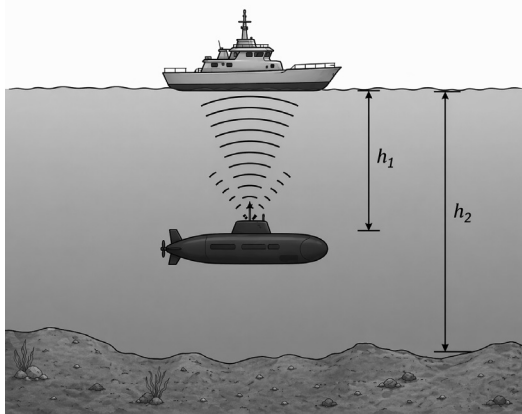
During sound propagation, the physical particles of the medium never travel from the source to the listener. They merely oscillate back and forth around their original mean positions. It is

- (D) The linear distance measured directly between two consecutive compressions or two consecutive rarefactions.

Ans : (D)

The wavelength, commonly denoted by the Greek letter lambda (λ), is the precise physical length of one complete wave cycle. In any longitudinal sound wave, this measurement is taken as the exact linear distance between the centers of two consecutive compressions or the centers of two immediately consecutive rarefactions.

28. A marine vessel is utilizing sound navigation technology to scan the waters below. If the vessel detects a reflection after a specific time interval, which depth is the system primarily measuring in this instance, and what category of sound waves is typically employed?



- (A) h_1 ; Infrasonic waves
 (B) h_2 ; Ultrasonic waves
 (C) h_1 ; Ultrasonic waves
 (D) h_2 ; Audible sound waves

Ans : (C)

Sonar systems utilize ultrasonic waves (frequencies above 20 kHz) because they travel well through water and can accurately reflect off objects. In this diagram, the wave reflects directly off the intermediate object (submarine), meaning the calculated distance using the echo time will yield the depth of the submarine (h_1), not the seabed.

29. A distinct sound wave propagating steadily through a uniform medium possesses a measured frequency of 200 Hz and an exactly determined wavelength of 1.5 m. What is the calculated speed of this sound wave?
 (A) 30 m/s
 (B) 150 m/s

- (C) 300 m/s
 (D) 450 m/s

Ans : (C)

The wave speed equation states that wave speed (v) equals the product of its wavelength (λ) and its frequency (ν). Applying the given numerical values to the standard formula,

we calculate $v = 1.5\text{m} \times 200\text{Hz}$.

This simple multiplication yields a total wave speed of precisely 300 m/s.

30.

Consider the following key statements regarding the actual speed of a sound wave propagating through various physical environments:

1. The speed of sound strictly depends on the physical state of the material medium.
2. An increase in the ambient air temperature causes a measurable increase in the speed of sound.
3. The speed of sound remains entirely constant regardless of any changes in ambient humidity.

Which of the statements given above are completely correct?

- (A) 1 and 2 only
 (B) 2 and 3 only
 (C) 1 and 3 only
 (D) 1, 2, and 3

Ans : (A)

Sound speed is heavily dependent on the physical medium, generally travelling much faster in solids than in gases. Furthermore, higher air temperatures increase particle kinetic energy, raising the sound speed. However, higher ambient humidity also increases the speed of sound, meaning the third statement is factually incorrect and misleading.

31. **Assertion (A):** The absolute speed of sound travelling in solid steel is significantly greater than its speed propagating through open atmospheric air.

Reason (R): Sound waves generally travel fastest in solid media, comparatively slower in liquids, and slowest of all in gaseous media.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

50. A hiker shouts loudly while facing a massive sheer mountain cliff. What is the calculated minimum physical distance required between the shouting source and the reflecting cliff surface to clearly hear a distinct echo, assuming the sound speed is exactly 344 m/s?
- (A) 17.2 meters
(B) 34.4 meters
(C) 68.8 meters
(D) 344 meters

Ans : (A)

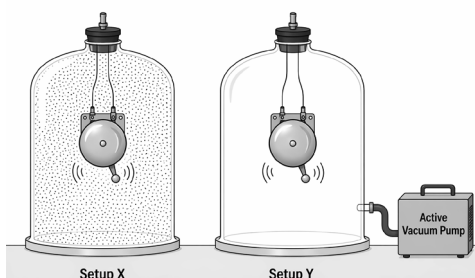
To hear a distinct echo, sound must travel to a barrier and return, taking at least 0.1 seconds. Using the formula

$$d = \frac{v \times t}{2},$$

we calculate distance as $(344 \times 0.1)/2$.

This straightforward calculation yields a mandatory minimum obstacle distance of exactly 17.2 meters.

51. Two identical experimental setups are created to observe the propagation of sound. Based on the physical conditions shown inside each container, what is the correct observation regarding the sound produced by the bells?



- (A) The sound will be clearly heard from both setups equally.
(B) The sound will be heard from Setup X but not from Setup Y.
(C) The sound will be heard from Setup Y but not from Setup X.
(D) The pitch of the sound from Setup Y will be significantly higher than Setup X.

Ans : (B)

Sound is a mechanical wave that requires a material medium to propagate. Setup X contains air particles that transmit the bell's vibrations outward. Setup Y represents a vacuum where no medium exists to carry the vibrations.

Consequently, the ringing bell in Setup Y cannot be heard, proving sound cannot travel through a vacuum.

52. The human brain retains auditory impressions for a brief fraction of time. What is the absolute minimum time gap required between hearing an original sound and its subsequent reflection to perceive them clearly as two entirely separate sounds (an echo)?
- (A) 0.01 seconds
(B) 0.05 seconds
(C) 0.1 seconds
(D) 1.0 seconds

Ans : (C)

The human auditory system naturally exhibits a sensory persistence of sound. Our brain essentially holds onto an acoustic impression for roughly 0.1 seconds. Consequently, for an echo to be perceived as a distinctly separate event rather than a prolonged blur, the reflected wave must arrive at least 0.1 seconds later.

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53. Consider the following architectural methods potentially used within a newly constructed concert auditorium:
1. Installing dense, sound-absorbing acoustic panels directly on the bare walls.
 2. Utilizing heavily upholstered seating instead of hard wooden chairs.
 3. Constructing completely flat, polished metallic walls behind the main stage area.
- Which of the aforementioned methods actively help purposefully reduce unwanted reverberation?
- (A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2, and 3

Ans : (A)

Reverberation is the disruptive prolongation of sound caused by rapid, continuous multiple reflections. Architects combat this by strategically introducing sound-absorbing materials. Soft, porous acoustic panels and heavily upholstered chairs successfully absorb excess acoustic energy. Conversely, hard, flat polished metallic walls would severely worsen reverberation by perfectly reflecting sound waves.

Timbre, frequently referred to as sound quality, is the specific acoustic characteristic that allows human listeners to distinctly differentiate between multiple sounds that possess the identical pitch and loudness. It inherently arises from the unique physical material, physical construction, and complex combination of harmonic overtones produced by different instruments.

37. An individual observes a brilliant flash of lightning in the distant sky and subsequently hears the booming thunder exactly 4 seconds later. Assuming the speed of sound in the air is approximately 340 m/s, how far away did the lightning physically strike?
- (A) 85 m
(B) 344 m
(C) 680 m
(D) 1360 m

Ans : (D)

Light travels incredibly fast, arriving almost instantaneously, whereas sound travels much slower. The physical distance can be accurately calculated using the standard formula: Distance equals Speed multiplied by Time. By multiplying the sound speed (340 m/s) by the measured time delay (4 s), the total distance calculated is exactly 1360 meter.

38. Consider the following detailed statements concerning how the measured speed of sound inherently varies within different surrounding physical environments:
1. Sound propagates about 15 times faster in dense solids than it does in gases.
 2. Increasing the ambient temperature of a gas invariably decreases the speed of sound.
 3. The absolute speed of sound in dry air at 0°C is approximately 331 m/s.
 4. The presence of atmospheric humidity actually serves to increase the measured speed of sound.

Which of the statements given above are entirely correct?

- (A) 1, 2, and 3 only
(B) 1, 3, and 4 only
(C) 2, 3, and 4 only
(D) 1, 2, 3, and 4

Ans : (B)

Sound travels considerably faster in dense solids compared to sparse gases. The known speed in air at 0°C is roughly 331 m/s, and elevated

humidity visibly increases this wave speed. However, the second statement is completely false because raising the ambient temperature actually continually increases the transmission speed of sound.

39. A sensor recorded the characteristics of four different sound sources. Which sound is audible to the human ear and will be perceived as the loudest?

Sound Source	Frequency (Hz)	Amplitude (cm)
W	15	2.0
X	5000	0.5
Y	10000	3.5
Z	25000	4.0

- (A) Sound W
(B) Sound X
(C) Sound Y
(D) Sound Z

Ans : (C)

The human audible range falls strictly between 20 Hz and 20,000 Hz, clearly eliminating sound W as infrasonic and sound Z as ultrasonic. Loudness is directly determined by the wave's amplitude. Among the remaining audible sounds X and Y, sound Y possesses a significantly higher amplitude, making it the loudest perceived sound.

40. In formal acoustics and traditional music theory, what precisely distinguishes a pure musical "tone" from standard everyday ambient sound?
- (A) A tone strictly consists of a single isolated frequency.
(B) A tone is entirely defined as an unpleasant mixture of multiple random frequencies.
(C) A tone is simply a sound containing absolutely zero measurable amplitude.
(D) A tone mathematically represents the measurable interval perfectly between two distinct notes.

Ans : (A)

In standard physics terminology, a pure tone is formally defined as a specific sound consisting of only one single, isolated acoustic frequency, perfectly exemplified by the sound a laboratory tuning fork generates. In contrast, standard everyday sounds and general musical notes usually contain a complex mixture of multiple distinct frequencies.

Both statements are entirely correct. The assertion correctly notes that sound travels much faster through solid steel (about 5000 m/s) than through atmospheric air (about 340 m/s). The provided reason perfectly explains this because sound propagation is inherently more efficient and faster in dense, closely packed solid materials.

- 32.** Arrange the following common material mediums in the correct ascending order based strictly on the measured speed of sound propagating through them at standard atmospheric conditions.

1. Liquid Water
2. Solid Steel
3. Gaseous Air

- (A) 3, 2, 1
(B) 1, 3, 2
(C) 3, 1, 2
(D) 2, 1, 3

Ans : (C)

Sound propagates by transferring mechanical kinetic energy between adjacent interacting particles. In sparsely packed gaseous air, this energy transfer is the slowest (approx. 340 m/s). In liquid water, it is notably faster (approx. 1500 m/s). In dense solid steel, it is exceptionally fast, reaching its highest speed (approx. 5000 m/s).

- 33.** Human auditory perception interprets various physical characteristics of sound waves subjectively. Which specific physical property of a sound wave directly determines whether a human perceives a sound as having a high pitch or a low pitch?

- (A) Wavelength
(B) Frequency
(C) Amplitude
(D) Speed

Ans : (B)

Pitch is purely the subjective human psychological perception of a sound wave's frequency. A sound wave containing a comparatively higher number of complete oscillations per second (high frequency) is universally interpreted by the human auditory system as a high-pitched sound, exactly like a sharp whistle or a small bird chirping.

- 34.** During a thunderous storm, a nearby loud clap of thunder forcefully shakes a home's windows, whereas a softly whispering wind barely makes a sound. Which specific physical characteristic of the sound wave primarily dictates this noticeable difference in overall loudness?

- (A) Time Period
(B) Frequency
(C) Wave Velocity
(D) Amplitude

Ans : (D)

The loudness of a sound is directly correlated with the physical amplitude of the underlying sound wave. A wave possessing a noticeably larger amplitude physically carries significantly more mechanical energy. Consequently, when this high-energy wave strikes the human eardrum, it induces much larger vibrations, resulting in a significantly louder sound.

- 35.** Students observed four different vibrating objects and recorded their oscillations. Which two objects produce sounds of the exact same pitch?

Vibrating Object	Number of Oscillations	Time Taken (s)
P	100	2.0
Q	200	5.0
R	150	1.5
S	50	0.5

- (A) P and Q
(B) Q and R
(C) R and S
(D) P and S

Ans : (C)

Pitch depends on the frequency of the sound wave. Frequency is calculated as the number of oscillations per unit time.

Object R has a frequency of $150/1.5 = 100$ Hz. Object S has a frequency of $50/0.5 = 100$ Hz. Since both share the exact same frequency, they produce sounds of identical pitch.

- 36.** Two immensely talented musicians are simultaneously playing the exact same musical note at the exact same loudness level, one utilizing a wooden flute and the other playing a stringed sitar. Despite identical volume and pitch, the sounds remain distinctly different. What specific sound quality permits this subjective differentiation?

- (A) Intensity
(B) Timbre
(C) Wavelength
(D) Oscillation

Ans : (B)

vibrates. The tiny middle ear bones physically amplify these vibrations. Finally, the deep inner ear's snail-shaped cochlea performs the vital task of converting these mechanical vibrations into electrical signals for brain processing.

- 46. Assertion (A):** A blindfolded human can surprisingly often pinpoint the precise spatial direction from which a sudden sound originated.

Reason (R): The human brain intelligently compares the minuscule time difference between the sound reaching the left and right ears.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

Having two spatially separated ears is an evolutionary advantage. When a sound originates off-center, it physically reaches one ear a tiny fraction of a second before the other. The human brain continuously processes this incredibly minuscule time gap, allowing us to accurately instinctively pinpoint the sound source's exact directional origin.

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- 47.** Extreme noise pollution represents a severe, growing environmental hazard. Prolonged exposure to acoustic levels exceeding recommended decibel limits can result in profound hearing loss. What specific medical test or diagnostic graph is routinely used to properly evaluate a patient's hearing loss?

- (A) Electrocardiogram
 (B) Seismogram
 (C) Audiogram
 (D) Sonogram

Ans : (C)

Unwanted, intense sound is categorized as harmful noise. Sustained exposure to highly elevated sound levels can tragically cause permanent hearing damage. To professionally medically evaluate an individual's hearing capability and accurately measure specific frequency loss, specialists administer a specialized diagnostic test that directly produces a detailed chart called an audiogram.

- 48.** When an acoustic wave physically strikes a large solid obstacle and subsequently bounces back, it strictly obeys the established scientific laws of reflection. Which of the following fundamental statements is completely true regarding sound reflection?

- (A) The angle of incidence is always significantly greater than the angle of reflection.
 (B) The reflected sound wave instantly travels at exactly double the original speed.
 (C) The angle of incidence equals the angle of reflection, and both lie in the same plane.
 (D) Sound waves strictly reflect only off highly polished, completely flat metallic mirrors.

Ans : (C)

Sound waves behave remarkably like light waves upon striking surfaces. They strictly adhere to the universal laws of reflection. Specifically, the incoming angle of incidence exactly equals the outgoing angle of reflection relative to the normal line, and all three imaginary lines strictly reside within the exact same geometric plane.

- 49.** A ship uses SONAR equipment to map the ocean floor. The speed of sound in seawater is taken as 1530 m/s. Based on the recorded data, what is the vertical difference in depth between the shipwreck and the reef?

Target	Total Time for Echo to Return (s)
Reef	1.0
Shipwreck	2.5
Trench	4.0

- (A) 765.0 m
 (B) 1147.5 m
 (C) 2295.0 m
 (D) 2677.5 m

Ans : (B)

Sonar depth is calculated using the formula

$$\text{Distance} = (\text{Speed} \times \text{Time}) / 2.$$

The reef is located at

$$(1530 \times 1.0) / 2 = 765 \text{ meters.}$$

The shipwreck is situated at

$$(1530 \times 2.5) / 2 = 1912.5 \text{ meters.}$$

The precise difference in their depths is 1912.5 minus 765, equaling 1147.5 meters.

81. Give one application of sound-absorbing materials like porous panels in modern concert halls.

Ans :

Sound-absorbing materials like porous panels are utilized in modern concert halls to reduce unwanted reverberations, ensuring that speech and music are heard clearly.

82. What is the frequency range of human audible sound?

Ans :

The frequency range of human audible sound, which a normal human ear can detect, is approximately from twenty hertz to twenty thousand hertz.

83. Give one example of an animal that utilizes echolocation to navigate in the dark.

Ans :

Bats are a classic example of animals that utilize echolocation by emitting ultrasonic waves to navigate and hunt for prey in complete darkness.

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84. What is the full form of SONAR and what is it used for?

Ans :

SONAR stands for Sound Navigation and Ranging, and it is primarily used for determining the distance, direction, and speed of underwater objects like submarines.

85. State one significant medical application of ultrasonic waves.

Ans :

Ultrasonic waves are highly utilized in medicine for imaging internal human organs safely without invasive surgery and for breaking kidney stones into smaller pieces.

86. What would happen if a sound wave's frequency drops below 20 Hz?

Ans :

If a sound wave's frequency drops below twenty hertz, it becomes an infrasonic wave, which cannot be heard by the normal human ear.

87. How does having two ears help humans in sound perception?

Ans :

Having two ears allows the human brain to accurately pinpoint the exact direction of the sound origin by comparing the tiny time gap differences.

88. Who discovered the Raman Effect in light and studied the acoustics of Indian percussion instruments?

Ans :

Sir C. V. Raman discovered the Raman Effect in light and made significant contributions to acoustics by studying Indian percussion instruments like the tabla.

89. What is the result of a supersonic aircraft flying at a speed higher than the speed of sound?

Ans :

A supersonic aircraft produces a sudden, massive disturbance in air density that travels outward, resulting in an extremely loud noise known as a sonic boom.

SHORT ANSWER QUESTIONS

Explain the mechanism by which human beings produce sound while talking or singing.

Ans :

In humans, sound is produced by the voice box or larynx, located in the throat. It contains two vocal cords, which are stretched muscular flaps. When we speak or sing, air from the lungs is forced through the narrow slit between the vocal cords. This forced air causes the vocal cords to vibrate, which in turn produces sound. The tongue, lips, mouth, and nasal cavity then help convert this raw sound into coherent speech or music. The tightening or loosening of these cords changes the sound's frequency.

91. Describe the vacuum bell jar experiment and state the fundamental property of sound it demonstrates.

Ans :

The vacuum bell jar experiment demonstrates that sound needs a material medium to travel.

54. While testing an empty enclosed room, a technician notices that a single loud clap results in a sound that continuously persists, blurs, and fades slowly rather than returning as one sharp distinct repetition. What specific acoustic phenomenon is this technician directly observing?
- Infrasonic emission
 - Single Echo reflection
 - Destructive interference
 - Reverberation

Ans : (D)

When sound reflects multiple times rapidly within an enclosed space, the individual echoes overlap, arriving at the ear with time differences smaller than 0.05 seconds. This continuous multiple reflection causes the sound to physically persist and painfully blur together, a very distinct acoustic phenomenon formally identified as reverberation.

55. Acoustic science mathematically categorizes mechanical sound waves entirely based on their measured frequency. Which specific frequency range correctly defines a wave categorized strictly as an ultrasonic wave?
- Frequencies strictly below 20 Hz.
 - Frequencies falling exactly between 20 Hz and 20,000 Hz
 - Frequencies strictly higher than 20,000 Hz.
 - Any mechanical wave traveling faster than the standard speed of light.

Ans : (C)

Sound waves are meticulously classified by their oscillation rates. Audible sound ranges from 20 Hz to 20 kHz. Waves vibrating below 20 Hz are termed infrasonic. Crucially, high-frequency sound waves oscillating faster than the upper human limit of 20,000 Hz (20 kHz) are formally classified as ultrasonic waves.

56. Many nocturnal animals navigate brilliantly without relying on visual sight. How exactly do nocturnal bats successfully utilize high-frequency ultrasonic waves to locate tiny flying prey precisely in complete environmental darkness?
- By directly heating the surrounding air to detect thermal changes.
 - By emitting bursts of ultrasound and carefully analyzing the returning reflected echoes.
 - By naturally vibrating their wings at exact infrasonic frequencies to stun prey.

- By constantly absorbing ambient sound waves completely from their surrounding environment.

Ans : (B)

Bats flawlessly hunt at night utilizing an advanced biological technique called echolocation. They continuously emit rapid bursts of high-frequency ultrasonic waves from their mouths. When these specialized waves strike small flying insects, they immediately reflect backward. The bat's sensitive ears analyze these returning echoes to pinpoint the prey's exact location.

57. Consider the following diverse list of specialized modern technological and medical applications:
- Non-invasively imaging human internal organs without required surgery.
 - Safely breaking dangerous internal kidney stones into minute flushable pieces.
 - Precisely locating deeply submerged underwater shipwrecks and opposing submarines.
 - Detecting hidden microscopic structural cracks deep inside thick metallic blocks.
- Which of these practical applications fundamentally rely on the controlled use of ultrasonic waves?
- 1 and 2 only
 - 3 and 4 only
 - 1, 3, and 4 only
 - 1, 2, 3, and 4

Ans : (D)

High-frequency ultrasonic waves possess immense practical utility due to their profound penetrative power and precise reflection capabilities. They are extensively used daily in non-invasive medical imaging, therapeutically shattering kidney stones, industrially detecting internal flaws within thick metal components, and powerfully operating maritime sonar systems to locate submerged underwater objects.

58. A heavily equipped naval survey ship transmits a powerful vertical sonar pulse deep into seawater. The reflected signal successfully returns to the specialized onboard detector exactly 2.0 seconds later. If sound travels at exactly 1530 m/s in this seawater, how deep is the ocean floor?
- 765 meters
 - 1530 meters
 - 3060 meters
 - 6120 meters

41. According to established physical principles, what is the primary underlying reason the propagating speed of a mechanical sound wave measurably increases when the surrounding air temperature is significantly elevated?
- (A) High temperatures automatically destroy the physical material medium.
 (B) Increased ambient temperature drastically reduces the physical wavelength to zero.
 (C) Increased temperature elevates particle kinetic energy, allowing significantly faster energy transfer.
 (D) Elevated atmospheric temperatures entirely remove the fundamental necessity for an acoustic medium.

Ans : (C)

When the localized temperature of any physical medium significantly rises, the individual constituent particles inherently gain substantial kinetic energy. This added energy causes them to vibrate with greater intensity and interact more rapidly with neighboring particles. Consequently, the mechanical acoustic energy transfer naturally occurs much faster, increasing the sound's speed.

42. In traditional Indian classical music notation, select the sequential order of basic musical notes that accurately represents an incrementally ascending order of corresponding acoustic wave frequencies.
- (A) Ni, Dha, Pa, Ma
 (B) Sa, Re, Ga, Ma
 (C) Pa, Ma, Ga, Re
 (D) Dha, Pa, Re, Sa

Ans : (B)

In formal Indian classical music traditions, the fundamental musical notes are arranged in a specific ascending sequence: Sa, Re, Ga, Ma, Pa, Dha, Ni. Moving progressively from 'Sa' forward through this scale, the fundamental acoustic frequency of each consecutive sung or played note incrementally and consistently increases in measurable value.

43. The human auditory system is an incredibly complex biological mechanism, but it undeniably possesses specific inherent physical limitations. What is the generally accepted audible frequency range for a healthy human ear?
- (A) 10 Hz to 10,000 Hz
 (B) 20 Hz to 20,000 Hz
 (C) 50 Hz to 50,000 Hz

(D) 100 Hz to 1,00,000 Hz

Ans : (B)

A typical healthy human ear can successfully detect mechanical sound waves ranging only from frequencies of roughly 20 Hz at the lower end up to 20,000 Hz (20 kHz) at the upper limit. Frequencies falling outside this specific biological window are completely inaudible to normal human auditory sensory perception.

44. A researcher claps in front of different reflecting surfaces and records the conditions. In which experiments will the researcher hear a distinct echo?

Experiment	Speed of Sound in Medium (m/s)	Distance to Reflecting Surface (m)
1	340	15
2	340	20
3	1500	50
4	1500	100

- (A) 1 and 3 only
 (B) 2 and 4 only
 (C) 1, 2, and 4
 (D) 3 and 4 only

Ans : (B)

A distinct echo requires a minimum time interval of 0.1 seconds between the original and reflected sound.

Using the formula $\text{Time} = (2 \times \text{Distance}) / \text{Speed}$, Experiment 2 yields 0.117 seconds and Experiment 4 yields 0.133 seconds. Both accurately meet the required condition for an echo to be clearly distinguished.

45. Within the intricate anatomical structure of the inner human ear, which crucial biological component is primarily responsible for converting mechanical acoustic vibrations into transmittable electrical neural signals?

- (A) The external pinna
 (B) The tympanic eardrum
 (C) The spiral cochlea
 (D) The tiny middle ear bones

Ans : (C)

The human ear comprises several intricate, functioning parts. The outer eardrum initially captures acoustic waves and mechanically

68. How is a longitudinal wave different from a transverse wave regarding particle vibration?

Ans :

In longitudinal waves, particles vibrate parallel to the wave propagation direction, whereas in transverse waves, particles vibrate perpendicular to the wave propagation direction.

69. What would you observe if you place salt grains on a stretched rubber sheet over a bowl and make a loud sound nearby?

Ans :

You would observe the salt grains jumping and moving on the sheet, demonstrating that sound transfers energy through the medium and causes vibrations.

70. What is the specific function of a microphone in sound technology?

Ans :

A microphone functions by capturing sound waves from various sources and converting this acoustic energy into an electrical signal for recording or amplification.

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71. What is meant by the crest of a sound wave in a density-distance graph?

Ans :

In a density-distance graph, the crest is the highest point on the curve, representing the region of maximum density and pressure, called compression.

72. What does the horizontal dashed line represent in the graphical representation of a sound wave?

Ans :

The horizontal dashed line in the graphical representation of a sound wave represents the average density of the medium when no sound is propagating.

73. Define the wavelength of a sound wave.

Ans :

The wavelength of a sound wave is defined as the distance between two consecutive crests or two consecutive troughs in its graphical representation.

74. What is the SI unit of the frequency of a sound wave?

Ans :

The SI unit of the frequency of a sound wave is hertz, which is symbolized as Hz and represents one oscillation per second.

75. Write the formula showing the relationship between wave speed, wavelength, and frequency.

Ans :

The formula relating these quantities is that the speed of a wave equals the product of its measured wavelength and its calculated frequency.

76. What determines the loudness of a sound perceived by the human ear?

Ans :

The loudness of a sound is primarily determined by its amplitude; sounds with larger amplitudes are perceived by humans as much louder sounds.

77. State one characteristic of sound that allows you to distinguish between different musical instruments playing the same note.

Ans :

Timbre is the characteristic of sound that allows us to distinguish between different musical instruments playing the exact same note at the same loudness.

78. What is the effect of an increase in air temperature on the speed of sound?

Ans :

As the temperature of the air increases, the speed of sound travelling through it also increases due to the faster movement of air particles.

79. Under what condition can a human distinctively hear an echo?

Ans :

To distinctively hear an echo, the time interval between the original sound and the reflected sound reaching our ears must be at least 0.1 seconds.

80. What causes the phenomenon of reverberation in a large auditorium?

Ans :

Reverberation is caused by the multiple reflections of sound from the walls and ceiling, making the sound persist even after the source stops emitting.

Ans : (B)

Sonar calculates depth by measuring round-trip travel time. The total time taken is 2.0 seconds, meaning the time strictly to reach the bottom is exactly 1.0 seconds.

Using the standard formula

$$d = v \times t,$$

$$= 1530 \times 1.0 \text{ s} = 1530 \text{ meter}$$

The accurately calculated depth is precisely 1530 meters.

- 59.** While many animals share the human audible range, some possess distinctly different capabilities. Which of the following massive land animals is scientifically known to communicate across vast distances using extremely low-frequency infrasonic waves?

(A) Small common household bats
(B) African and Asian Elephants
(C) Bottlenose dolphins
(D) Common household dogs

Ans : (B)

While bats and dolphins famously utilize high-frequency ultrasonic waves for advanced echolocation, massive land mammals employ entirely different methods. Scientific studies confirm that elephants, alongside rhinoceroses and whales, successfully generate and detect extremely low-frequency infrasonic waves (below 20 Hz) to securely communicate with each other over immensely large physical distances.

VERY SHORT ANSWER

- 60.** What is vibration in the context of sound production?

Ans :

Vibration refers to the periodic and rapid backward and forward motion or oscillations of an object, which is the primary cause of sound production.

- 61.** Name the specific parts that vibrate to produce sound in humans.

Ans :

In humans, sound is produced by the vibration of vocal cords, which are tightly stretched muscular flaps located inside the voice box or larynx.

- 62.** What instrument is frequently used in science laboratories to perform experiments related to sound production?

Ans :

A tuning fork, which is a U-shaped metal bar with a stem and two prongs, is frequently used for conducting laboratory experiments with sound.

- 63.** Define the term 'medium' in the context of sound propagation.

Ans :

A medium is defined as any solid, liquid, or gaseous material substance through which sound waves can travel or propagate from their original source.

- 64.** What is the significance of the vacuum bell jar experiment?

Ans :

The vacuum bell jar experiment clearly demonstrates that sound requires a material medium to propagate and cannot travel through a vacuum or empty space.

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- 65.** Give one reason why astronauts on a spacewalk cannot hear each other directly.

Ans :

Astronauts cannot hear each other directly because outer space is a near vacuum, and sound waves require a material medium to propagate and travel.

- 66.** State one difference between a compression and a rarefaction in a sound wave.

Ans :

A compression is a region of higher air density and pressure, whereas a rarefaction is a region of lower air density and pressure within waves.

- 67.** What is the scientific term for waves that require a material medium for their propagation?

Ans :

Waves that strictly require a material medium, such as a solid, liquid, or gas, for their propagation are scientifically known as mechanical waves.

An electric bell is suspended inside an airtight glass bell jar connected to a vacuum pump. When the bell is switched on, its sound is clearly heard. As the vacuum pump removes air from the jar, the sound of the bell gradually becomes fainter. Finally, when a near vacuum is created inside the jar, almost no sound is heard even though the bell's hammer continues striking. This proves sound cannot travel through a vacuum.

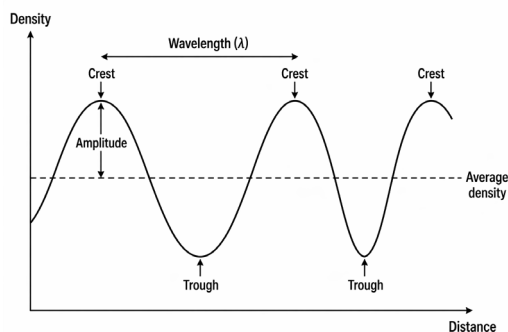
92. Explain how a sound wave propagates through air using the concepts of compressions and rarefactions.

Ans :

When a sound source vibrates, it pushes nearby air particles forward, creating a region of higher pressure and density called a compression. These compressed particles collide with adjacent particles, passing the disturbance forward. As the source moves backward, it creates a region of lower pressure and density called a rarefaction. As the source continues oscillating, alternate compressions and rarefactions are produced. These alternating regions travel outward through the medium as a sound wave, transferring energy without the actual forward movement of the air particles themselves.

93. Draw a density-distance graph for a propagating sound wave marking crest, trough, wavelength, and amplitude. Explain what wavelength mathematically represents.

Ans :



A density-distance graph visually represents how the medium's density fluctuates as a sound wave passes through it. The crest marks the maximum density during a compression, while the trough signifies the minimum density during a rarefaction. Wavelength, denoted by λ , is the exact

physical distance between two consecutive crests or two consecutive troughs. It fundamentally represents the length of one complete wave cycle in the medium. Understanding this wavelength helps scientists determine the speed of the wave if the frequency of the sound source is already known.

94. Define the speed of sound and mathematically derive its relationship with wavelength and frequency.

Ans :

The speed of sound is the distance a point on a wave, like a crest or trough, travels in unit time. For a wave of given frequency, the distance between two consecutive crests is exactly one wavelength. This specific distance is covered by the disturbance in exactly one time period. Since speed equals distance divided by time, we write speed equals wavelength divided by time period. Since frequency is the reciprocal of the time period, the speed of sound is effectively equal to wavelength multiplied by frequency.

95. Explain the difference between the intensity of a sound wave and its loudness.

Ans :

Intensity of sound is defined as the amount of sound energy passing through a unit area perpendicular to the direction of wave propagation in a unit time. It is a strictly physical, measurable quantity independent of the listener. In contrast, loudness refers to the physiological response or human perception of a sound wave's amplitude. While intensity is an absolute measure, loudness depends significantly on the listener's hearing sensitivity. Therefore, two sounds of equal intensity may be perceived as having different loudness by different individuals with varying hearing abilities.

96. Explain the phenomenon of reverberation and describe how it is practically reduced in modern auditoriums.

Ans :

Reverberation is the persistence of sound in a large enclosure, such as an auditorium, due to repeated or multiple reflections from the walls, ceiling, and floor even after the source stops emitting sound. If the time gap between reflected sounds is less than 0.05 seconds, they blur together. To reduce unwanted reverberations that garble speech and

particles are widely separated, making energy transfer through random collisions considerably slower and less efficient.

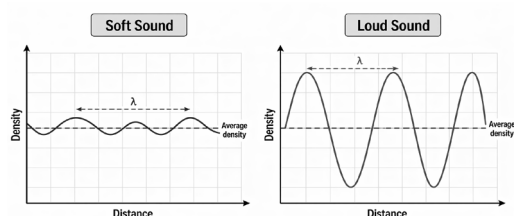
117. Why is the bright flash of lightning seen significantly earlier than the rumbling sound of thunder is heard during a severe storm? Explain with scientific principles.

Ans :

During a thunderstorm, lightning and thunder are essentially produced at the exact same moment. However, we always see the bright flash of lightning significantly earlier than we hear the accompanying crash of thunder. This delay happens because light and sound travel at enormously different speeds. Light travels through the atmosphere at approximately 300 million meters per second, reaching our eyes almost instantaneously. In sharp contrast, sound travels through the air at roughly 340 meters per second, taking several seconds to cover the exact same distance to our ears.

118. Draw the graphical representation of two sound waves having the exact same frequency but completely different amplitudes. Which wave represents a louder sound and why?

Ans :



The second wave clearly represents a much louder sound. Loudness is physiologically determined by the amplitude of the incoming sound wave, which is the maximum deviation of the medium's density from its normal average level. A larger amplitude means the original vibrating source was struck with considerably more force, transferring greater kinetic energy to the surrounding air particles. This highly energetic wave travels outwards and forcefully strikes the eardrum with more intensity, causing the human brain to perceive the sound as noticeably louder than the first wave.

119. What would hypothetically happen to our acoustic environment if sound waves completely lost their

ability to be reflected by hard surfaces? Describe two practical consequences.

Ans :

If sound waves completely lost the fundamental ability to reflect off hard surfaces, our world would experience several drastic acoustic changes. Firstly, the famous phenomena of echoes and reverberation would entirely cease to exist, making large empty halls sound completely dead and unnaturally quiet. Secondly, crucial navigation technologies like marine SONAR would become entirely useless, making underwater submarine tracking and depth calculation impossible. Finally, nocturnal animals like bats and dolphins would tragically lose their biological echolocation abilities, leaving them completely unable to hunt or navigate safely in darkness.

LONG ANSWER QUESTIONS

120. (a) Describe the vacuum bell jar experiment to show that sound needs a medium to propagate?
(b) Based on this observation, what type of wave is sound?
(c) Draw a well-labelled diagram of the experimental setup?

Ans :

- (a) An experiment to demonstrate that sound requires a material medium is the vacuum bell jar experiment. The setup consists of an electric bell suspended inside an airtight glass bell jar, which is placed on a base connected to a vacuum pump. Initially, when the bell is switched on, its ringing sound is clearly heard because the jar is filled with air. As the vacuum pump gradually removes the air from the jar, the loudness of the sound steadily decreases, even though the hammer continues to strike the gong. Eventually, when a near vacuum is created, the sound becomes almost inaudible.
(b) This observation proves that sound is a mechanical wave. Unlike electromagnetic waves, sound cannot travel through empty space. It fundamentally relies on the collisions of particles in a physical medium, such as a solid, liquid, or gas, to propagate and transfer energy.

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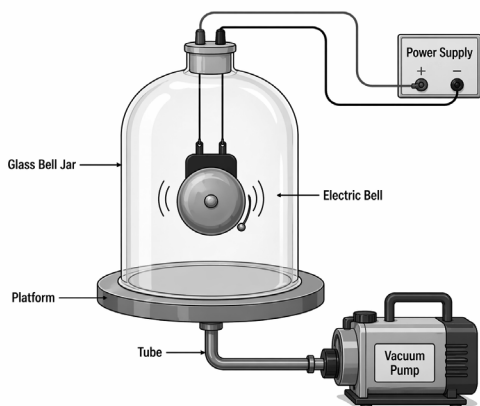
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- 101.** Explain a simple activity using a stretched sheet to demonstrate that sound carries physical energy.

Ans :

To demonstrate that sound carries energy, stretch a rubber sheet or cellophane tightly over the mouth of a wide container and secure it with a rubber band. Evenly sprinkle some light grains, like rice or semolina, on top of this sheet. Produce a very loud sound by striking a metal plate near the container without touching it. You will observe that the grains start jumping on the sheet. The sound wave propagates through the air, strikes the rubber sheet, transfers its energy, and forces the sheet to vibrate.

- 102.** Study the given diagram of an experimental setup.



Identify the experiment shown. What happens to the sound of the bell as the air is slowly removed, and what scientific conclusion can be drawn?

Ans :

The given diagram represents the famous vacuum bell jar experiment. It is specifically designed to prove that sound essentially requires a material medium to propagate. When the electric bell rings initially, the sound is loud. However, as the vacuum pump actively sucks the air out of the sealed jar, the air density decreases drastically. Consequently, the ringing sound becomes progressively fainter. Once a near-vacuum state is achieved inside the jar, the sound vanishes entirely. This conclusively proves that mechanical sound waves cannot travel through an empty vacuum.

- 103.** Define frequency and time period of a sound wave. How are they mathematically related to each other?

Ans :

The frequency of a sound wave is the number of complete density oscillations occurring at a fixed point per unit time, measured in Hertz. The time period is the time taken to complete exactly one full density oscillation at that point, measured in seconds. They are inversely related to each other. Mathematically, frequency equals one divided by the time period. A shorter time period means the wave completes its cycles much faster, which directly corresponds to a higher frequency and, consequently, a higher pitch in human perception.

- 104.** What are mechanical waves? Give one example each of longitudinal and transverse waves.

Ans :

Mechanical waves are waves that absolutely require a material medium, such as a solid, liquid, or gas, for their propagation. They cannot travel through a vacuum. A sound wave travelling through the air is a primary example of a longitudinal mechanical wave, where medium particles vibrate parallel to the wave's direction. Conversely, waves formed on the surface of water or ripples on a string represent transverse mechanical waves, where the particles of the medium vibrate perpendicular to the exact direction of the wave's forward propagation.

- 105.** Define the pitch of a sound. How does it relate to the frequency of the sound wave?

Ans :

Pitch is entirely the subjective way the human brain interprets the frequency of an emitted sound. It allows us to distinguish between a shrill voice and a deep, rumbling voice. Pitch is directly proportional to the frequency of the sound wave. High-pitch sounds, such as a referee's whistle or a child's voice, correspond to a high frequency, meaning many oscillations per second. Low-pitch sounds, like the roar of a lion or an aircraft engine rumble, correspond to lower frequencies with fewer oscillations passing a point per second.

- 106.** What are infrasonic and ultrasonic waves? State the typical audible hearing range for healthy humans.

Ans :

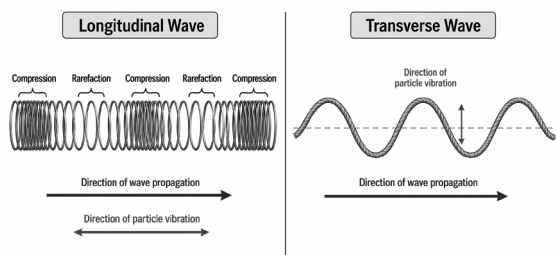
Infrasonic waves are low-frequency sound waves that fall strictly below 20 Hertz, which some animals like elephants and rhinoceroses use for communication. Ultrasonic waves are high-

- (b) The quality, or timbre, is an essential characteristic of sound that allows the human ear to distinguish between different musical instruments playing the exact same note at identical loudness. When instruments like a sitar or a flute play, they produce unique sets of overtones. The specific mathematical pattern, number, and relative intensity of these varying overtones give each individual instrument its highly distinctive and recognizable auditory waveform.

129. (a) Differentiate between longitudinal and transverse waves using a diagram that shows the directions of particle vibration?
 (b) Which specific type of wave is sound propagating in atmospheric air?
 (c) Explain briefly how human beings produce these sound waves using their anatomical structures?

Ans :

(a)



In a longitudinal wave, the constituent particles of the medium vibrate back and forth in a direction strictly parallel to the direction of wave propagation, resulting in alternating high-pressure compressions and low-pressure rarefactions. Conversely, in a transverse wave, the medium's particles oscillate up and down perpendicularly to the wave's forward path, creating visible crests and troughs.

- (b) Sound propagating through atmospheric air is a classic example of a longitudinal wave.
 (c) Humans generate these sound waves using the voice box, scientifically known as the larynx, located in the throat region. Inside the larynx, two muscular flaps called vocal cords are stretched tightly across the opening, leaving a very narrow slit. When the lungs forcefully exhale air through this tiny slit, the vocal cords vibrate rapidly. This continuous vibration produces sound. Humans modify

the pitch of their voice by adjusting the muscular tension and thickness of these vocal cords.

NUMERICAL QUESTIONS

130. A person fires a gun standing at a distance of 55 m from a wall. If the speed of sound is 330 ms^{-1} , find the time for an echo to be heard.

Ans :

Given, distance, $d = 55 \text{ m}$,

Speed of sound $v = 330 \text{ ms}^{-1}$, $t = ?$

As we know that,

$$2d = v \times t$$

$$\text{or} \quad t = \frac{2d}{v} = \frac{2 \times 55}{330} = 0.3 \text{ s}$$

131. A tuning fork produces 1024 waves in 4 seconds. Calculate the frequency to the tuning fork.

Ans :

As the tuning fork produces 1024 waves in 4 seconds, hence

Frequency of tuning fork,

$$\begin{aligned} \nu &= \text{Number of vibration per second} \\ &= \frac{1024}{4} = 256 \text{ Hz} \end{aligned}$$

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132. A human heart, on an average, is found to beat 75 times a minute. Calculate its frequency.

Ans :

Given, No. of beats of human heart

$$= 75 \text{ min}^{-1}$$

$$= \frac{75}{1} \text{ min}$$

$$= \frac{75}{60} \text{ s} = 1.25 \text{ s}^{-1}$$

So, average frequency of human heart beating = 1.25 s^{-1} .

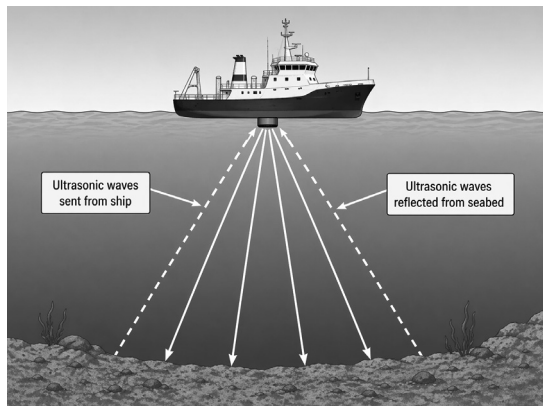
- 112.** A student claims, “Astronauts cannot talk directly to each other on the moon using their regular voice.” Is this statement scientifically correct? Justify your answer.

Ans :

Yes, this statement is entirely correct. Sound is a mechanical wave, meaning it strictly requires a physical material medium—such as a solid, liquid, or gas—for its energy to propagate from one point to another. The moon severely lacks a substantial atmosphere, resulting in a near-vacuum environment across its surface. Since there are virtually no air particles available to compress, rarefy and transfer the vibrational energy of their vocal cords, ordinary sound waves cannot travel. Astronauts must rely entirely on specialized radio communication devices inside their spacesuits.

- 113.** Draw a basic block diagram showing the transmission and reception of waves by a ship’s SONAR. Why are ultrasonic waves used instead of audible sound?

Ans :



SONAR systems exclusively use ultrasonic waves rather than ordinary audible sound for underwater navigation. Ultrasonic waves have significantly higher frequencies and shorter wavelengths, which allows them to travel in straight, narrow beams without scattering broadly in all directions. This tight beam ensures precise targeting of underwater objects like submarines or the seabed. Furthermore, ultrasonic waves carry substantial energy, enabling them to penetrate very deep ocean waters and return as a clear, detectable echo without being absorbed or completely dissipated by the vast volume of seawater.

- 114.** Your friend asserts, “When sound travels from a source to a listener, the air particles travel all the way from the source to the listener’s ear.” Do you agree? Provide justification.

Ans :

No, I completely disagree with this statement. When sound travels from a vibrating source to a listener, the individual air particles definitely do not travel the entire distance. Instead, the vibrating source merely pushes the immediate adjacent air particles, displacing them slightly from their rest positions. These particles collide with their neighbours, transferring the mechanical energy forward, and then immediately bounce back to their original mean positions. It is only the wave disturbance—the alternating pattern of energy—that travels the entire distance to the listener’s ear, not the matter.

- 115.** Compare longitudinal waves and transverse waves with respect to the specific direction of particle vibration relative to wave propagation. Give one example of each.

Ans :

In a longitudinal wave, the particles of the medium vibrate back and forth along a path that is strictly parallel to the direction of wave propagation. A standard sound wave travelling through the air is a classic example of this type. Conversely, in a transverse wave, the individual particles of the medium vibrate up and down in a direction that is perfectly perpendicular to the forward direction of wave propagation. Light waves or ripples moving across the surface of a pond are common examples of transverse waves.

- 116.** Compare the propagation of sound in solid and gaseous media with respect to its speed. Explain the primary scientific reason for this vast difference.

Ans :

The speed of sound dramatically depends on the physical nature of the propagating medium. Sound travels significantly fastest in solid materials, much slower in liquids, and entirely slowest in gaseous media like air. This vast difference occurs because the particles in a solid are packed extremely tightly together with very strong intermolecular forces. When a vibration occurs, these closely linked particles rapidly transmit the disturbance to their immediate neighbours. In gases, the

Ans :

- (a) Sound propagates through a medium by generating alternating regions of high and low pressure. When a source vibrates forward, it compresses adjacent air particles, creating a high-density region called a compression. When it moves backward, it leaves a low-density region called a rarefaction. These alternating compressions and rarefactions travel outward through the medium, transferring acoustic energy without causing a net forward movement of the particles themselves.
- (b) Sound is classified as a longitudinal wave because the individual particles of the medium vibrate back and forth in a direction strictly parallel to the direction of wave propagation.
- (c) Frequency is defined as the number of complete oscillations, or compressions, passing a fixed point per unit time.

Given:

Number of compressions

$$= 50, \text{ Time} = 2 \text{ s.}$$

Frequency

$$= \text{Number of compressions} / \text{Time taken}$$

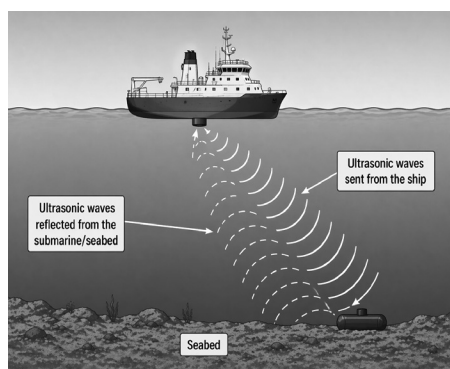
$$= 50 / 2 = 25 \text{ Hz.}$$

Therefore, the source has a frequency of 25 Hz.

124. (a) Draw a schematic diagram showing the functioning of SONAR on a ship?
- (b) Explain the fundamental principle it uses to determine the depth of the ocean?
- (c) A sonar signal takes 4 seconds to return from the seabed. If the speed of sound in seawater is 1500 m/s, calculate the depth?

Ans :

- (a)



- (b) SONAR stands for Sound Navigation and Ranging. It operates on the principle of echolocation using high-frequency ultrasonic waves. A transmitter mounted on the bottom of a ship sends directed pulses of ultrasonic waves downward into the seawater. These waves travel until they strike the seabed or an underwater object, and then reflect back upward as echoes. A sensitive detector on the ship receives these echoes. By measuring the exact time interval between transmission and reception, and knowing the speed of sound in water, the distance can be calculated.
- (c) In the given scenario, the total time for the signal to travel down and back is 4 seconds.
Time taken to just reach the seabed

$$= 4 / 2 = 2 \text{ s.}$$

Speed of sound in seawater = 1500 m/s.

$$\text{Depth} = \text{Speed} \times \text{Time}$$

$$\text{Depth} = 1500 \times 2 = 3000 \text{ m.}$$

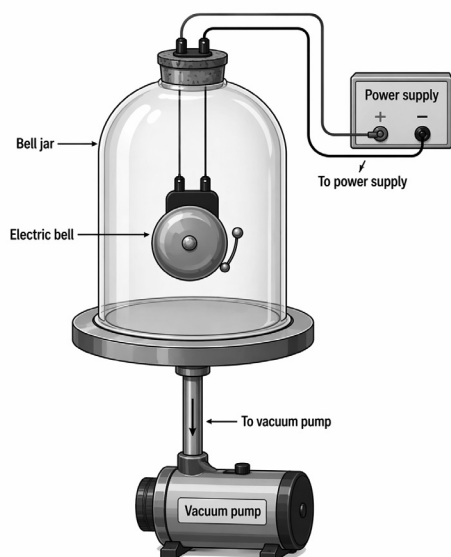
Thus, the ocean depth is 3000 metres.

125. (a) Describe a simple classroom activity using a tuning fork and a water surface to show that sound is produced by vibrating objects?
- (b) How does this specific activity also demonstrate that sound waves transfer energy rather than physical matter?

Ans :

- (a) To demonstrate that sound is generated by vibrating objects, strike a tuning fork gently against a soft rubber pad to initiate its vibration. Bring the vibrating tuning fork near your ear to clearly hear the sound produced. Next, hold a container completely filled with water and carefully touch the still water surface with one of the vibrating prongs. You will instantly observe small ripples or waves forming and spreading rapidly across the water surface, providing visual evidence that the metal prongs are oscillating.
- (b) This simple activity also beautifully demonstrates energy transfer. The vibrating tuning fork contains kinetic energy. Upon touching the water, it physically transfers this mechanical energy to the adjacent water particles. The water particles themselves only oscillate locally about their mean resting positions, but the resulting disturbance propagates outward as ripples. This establishes that waves transfer energy through a medium without any actual bulk transfer of matter.

(c)



121. (a) Differentiate between an echo and reverberation?
- (b) What are the minimum conditions of time and distance required to hear a distinct echo in air (assume the speed of sound as 340 m/s)?
- (c) How do architects systematically reduce unwanted reverberations in concert halls?

Ans :

- (a) An echo is a distinct, isolated reflection of sound from a distant hard surface, heard separately from the original sound. In contrast, reverberation is the continuous persistence of sound within an enclosed space due to multiple, overlapping reflections from walls and ceilings, which often makes speech unclear.
- (b) To hear a distinct echo, the human brain requires a time gap of at least 0.1 seconds between the original sound and the reflected sound.

Since sound travels to the reflecting surface and back, the total distance covered is twice the distance to the reflector (2d).

Using the relation

Distance = Speed $\times$ Time, we get

$$2d = 340 \times 0.1 = 34 \text{ m,}$$

$$d = 17 \text{ metres.}$$

Therefore, the reflecting surface must be at least 17 metres away from the source for a distinct echo to be heard in air.

- (c) Architects reduce unwanted reverberations by lining auditorium walls and ceilings with sound-absorbing materials like porous panels and heavy curtains.

122. (a) Differentiate clearly between the pitch and loudness of a sound?
- (b) On what specific physical wave quantities do these two characteristics respectively depend?
- (c) What is the normal audible range for human hearing, and how are sound waves falling outside this range classified?

Ans :

- (a) Pitch and loudness are subjective human characteristics used to describe our perception of sound. Pitch relates to how shrill, sharp, or deep a sound appears to the ear, whereas loudness refers to the intensity or volume of the sound.
- (b) Pitch depends fundamentally on the frequency of the sound wave; a higher frequency produces a higher-pitched sound, while a lower frequency produces a low-pitched, deep sound. Loudness depends primarily on the amplitude of the wave; larger amplitudes transfer more energy and create a louder sound.
- (c) The normal audible hearing range for humans spans from 20 Hz to 20,000 Hz. Sound waves with frequencies below 20 Hz are classified as infrasonic waves, which animals like elephants use to communicate. Conversely, sound waves with frequencies strictly above 20,000 Hz are termed ultrasonic waves, which are widely used by bats for navigation and in medical imaging technologies.

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123. (a) Explain how a sound wave propagates through a fluid medium using the concepts of compressions and rarefactions?
- (b) Why is sound specifically considered a longitudinal wave?
- (c) A vibrating tuning fork creates 50 compressions in 2 seconds; calculate its fundamental frequency?

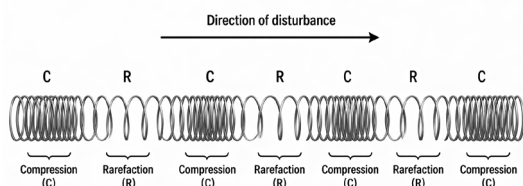
frequency sound waves exceeding 20,000 Hertz, commonly used by bats, dolphins, and in medical imaging devices like ultrasound scanners. The typical audible range for a healthy human ear is strictly between 20 Hertz and 20,000 Hertz. Therefore, humans cannot hear infrasonic or ultrasonic waves as they lie completely outside our biological hearing capacity, though this upper limit decreases naturally as people age.

- 107.** What is an echo? Calculate the minimum distance required to hear a distinct echo if the speed of sound is 344 m/s.

Ans :

An echo is the distinct repetition of a sound caused by the reflection of sound waves from a hard obstacle like a mountain or tall building. For an echo to be clearly distinguished by the human brain, the reflected sound must arrive at least 0.1 seconds after the original sound. If the speed of sound is 344 meters per second, the total distance travelled in 0.1 seconds is 34.4 meters. Since the sound must travel to the obstacle and back, the minimum distance required is exactly 17.2 meters.

- 108.** The diagram below shows a disturbance created in a toy.



Identify the specific regions marked C and R. What type of physical wave does this entire setup beautifully represent?

Ans :

The provided diagram illustrates the fundamental propagation of a longitudinal wave using a stretched slinky. The region clearly marked 'C' represents a compression, where the coils are crowded tightly together, simulating a high-density area in a sound wave. The region marked 'R' represents a rarefaction, where the coils are spread far apart, signifying a low-density area. When one end is pushed and pulled, these alternating compressions and rarefactions travel down the length of the slinky, exactly mimicking

how sound energy travels through a gaseous medium like air.

- 109.** Does sound travel at the same speed in all media? How does an increase in temperature affect the speed of sound in air?

Ans :

No, sound definitely does not travel at the same speed in all media. It travels fastest in solids, significantly slower in liquids, and slowest in gases. For example, sound is roughly 15 times faster in steel than in air. Furthermore, the speed of sound in a gas like air is directly dependent on physical properties such as temperature. As the temperature of the air increases, the kinetic energy of its molecules increases, which allows the sound disturbance to propagate noticeably faster through the warmer air mass.

- 110.** What is the amplitude of a sound wave? How does it directly affect the loudness of the sound perceived by humans?

Ans :

The amplitude of a sound wave is the maximum displacement of the medium's particles from their rest position, which equates to the maximum change in density or pressure from the average value. Amplitude directly determines the physical energy the wave carries. This directly affects the loudness, which is the physiological perception of that energy. A wave with a larger amplitude carries significantly more energy and is perceived as a much louder sound. A smaller amplitude transfers less energy, resulting in a sound perceived as very soft or faint.

- 111.** What is a tuning fork? How does its physical vibration produce sound in the surrounding air?

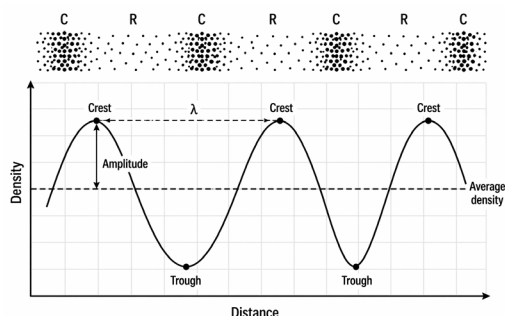
Ans :

A tuning fork is a U-shaped metallic bar, usually made of steel or aluminium, featuring two parallel prongs and a central stem. It is specifically designed to produce a pure, single-frequency sound for experiments. When struck against a soft rubber pad, the prongs are set into rapid vibration. As these prongs oscillate outward and inward, they push and pull the surrounding air molecules. This rapid displacement produces alternating regions of high pressure and low pressure, generating longitudinal sound waves that travel outward into the surrounding environment.

126. (a) Draw a graphical representation of a sound wave showing the variation of density with distance, labelling its key parts?
 (b) Define wavelength and frequency?
 (c) If a sound wave travels at 340 m/s with a frequency of 170 Hz, calculate its wavelength?

Ans :

(a)



The graphical representation plots the density of the medium on the y-axis against distance on the x-axis. Compressions form upper peaks called crests, representing regions of maximum density above the average level. Rarefactions form lower valleys called troughs, representing regions of minimum density. The amplitude is the maximum change in density from the central average density line.

- (b) Wavelength is the horizontal distance between two consecutive crests or two consecutive troughs, measured in metres. Frequency is defined as the number of complete density oscillations occurring per second, measured in Hertz.
 (c) For the numerical part, we use the wave equation:

$$\text{Speed} = \text{Wavelength} \times \text{Frequency}$$

Given the speed is 340 m/s and the frequency is 170 Hz:

$$\text{Wavelength} = \text{Speed} / \text{Frequency}$$

$$\text{Wavelength} = 340 / 170$$

$$\text{Wavelength} = 2 \text{ m}$$

Therefore, the wavelength of the given sound wave is exactly 2 metres.

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127. (a) State three environmental or physical factors that significantly affect the speed of sound propagating in a medium?
 (b) During a thunderstorm, a person sees lightning and hears thunder 5 seconds later. If the speed of sound in air is 340 m/s, calculate the distance to the lightning strike?

Ans :

- (a) The speed of sound depends primarily on the physical properties of the medium. First, it depends on the state of the medium; sound propagates much faster in solids than in liquids, and slowest in gases. Second, temperature significantly affects it; an increase in the temperature of a medium results in a higher speed of sound. Third, humidity levels in gases alter the speed, as sound travels faster in moist air compared to completely dry air.
 (b) For the mathematical calculation, the time delay between seeing the lightning flash and hearing the thunder is 5 seconds. Since light travels almost instantaneously, we consider this delay entirely as the time taken for sound to travel.

$$\text{Distance} = \text{Speed} \times \text{Time}$$

$$\text{Distance} = 340 \text{ m/s} \times 5 \text{ s}$$

$$\text{Distance} = 1700 \text{ m}$$

By converting metres to kilometres, we find that the lightning struck exactly 1.7 km away from the observer's current position.

128. (a) What do you understand by the specific terms tone and note in the context of musical acoustics?
 (b) How does the quality or timbre of sound help a listener distinguish between two different musical instruments playing the exact same note at the same loudness?

Ans :

- (a) In the study of acoustics, a tone refers to a sound that consists of a single, pure frequency. Such pure sounds are relatively rare in nature but can be produced by specific instruments like a tuning fork. In contrast, a note is a complex musical sound created by blending multiple frequencies simultaneously. A note comprises a fundamental base frequency mixed with several higher frequencies known as overtones, which makes it sound rich, full, and pleasant to the listener.

music, modern auditoriums use sound-absorbing materials. Panels made of compressed fibreboard, heavy curtains, and upholstered chairs are installed to absorb excess sound energy and prevent excessive bouncing of the sound waves.

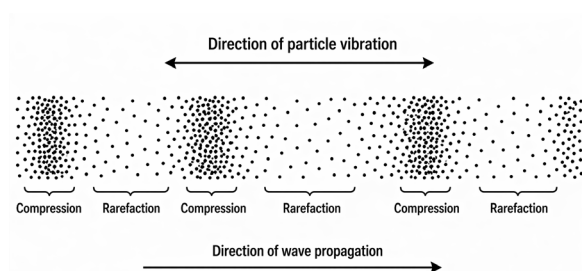
97. Explain the working principle of SONAR and mention its primary application.

Ans :

SONAR stands for Sound Navigation and Ranging. It is a device installed on ships or boats to detect the distance, direction, and speed of underwater objects like submarines, shoals of fish, or sunken ships. The SONAR transmitter sends out powerful ultrasonic waves into the water. When these waves strike an underwater object, they get reflected and return to the ship, where a receiver converts them back into electrical signals. By measuring the time taken for the echo to return, the depth or distance of the object is accurately calculated.

98. Draw a diagram illustrating a longitudinal wave showing the direction of particle vibration and wave propagation. Explain how particles behave in this wave.

Ans :



A longitudinal wave is one where the medium's particles vibrate back and forth along the exact same axis as the wave's forward motion. As the source vibrates, it pushes nearby particles, creating tightly packed high-pressure zones called compressions. When the source pulls back, it creates widely spaced low-pressure zones called rarefactions. The particles themselves do not travel across the room; they merely oscillate slightly around their mean rest positions. However, their repeated collisions transfer the disturbance energy forward steadily parallel to the direction of particle oscillation.

99. Describe the biological mechanism of echolocation and explain how bats utilize it.

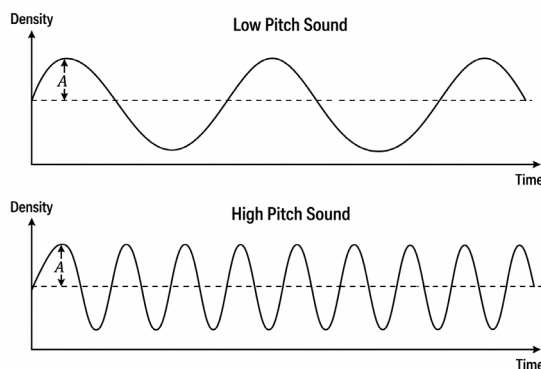
Ans :

Echolocation is the biological ability to locate objects using reflected sound waves. Bats are nocturnal mammals that rely heavily on this mechanism to navigate and hunt in complete darkness without colliding into obstacles. A bat emits short, high-frequency bursts of ultrasonic waves from its mouth or nose. These waves travel through the air and reflect off objects, such as a flying insect. The bat's highly sensitive ears detect the returning echoes. By analyzing the time delay and direction of the echoes, the bat precisely determines the prey's location.

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100. Draw the density-time graphs for a low-pitch sound and a high-pitch sound on separate axes. How do their structural frequencies fundamentally differ?

Ans :



Pitch entirely depends on the frequency of the sound wave. A low-pitch sound is produced by a source vibrating rather slowly, resulting in fewer wave cycles passing a point per second. Its graph displays long, spread-out waves with a lower frequency. In stark contrast, a high-pitch sound originates from a rapidly vibrating source, generating many more wave cycles per second. Its corresponding graph features tightly packed, narrow waves, clearly demonstrating a significantly higher frequency compared to the low-pitch sound, even if their amplitudes are completely identical.

- 133.** A boat at anchor is rocked by waves whose consecutive crests are 100 m apart. The wave velocity of the moving crests is 20 m/s. What is the frequency of rocking of the boat?

Ans :

Given,

Distance between two consecutive crests = 100 m

Wave velocity $v = 20$ m/s

The distance between two consecutive crests is equal to the wavelength of the wave. So,

$$\begin{aligned}\text{Frequency} &= \frac{\text{Wave velocity}}{\text{Wave length}} \\ &= \frac{20 \text{ m s}^{-1}}{100 \text{ m}} = 0.2 \text{ s}^{-1}\end{aligned}$$

So, the frequency of rocking of the boat is 0.2 s^{-1} .

- 134.** A longitudinal wave is produced on a toy slinky. The wave travels at a speed of 30 cm/s and the frequency of the wave is 20 Hz. What is the minimum separation between the consecutive compressions of the slinky?

Ans :

Given,

Wave speed, $v = 30$ cm/s

Frequency of the wave, $v = 20$ Hz = 20 s^{-1}

The minimum separation between the consecutive compressions is equal to the wavelength. Therefore,

$$\text{Wavelength} = \frac{30 \text{ cm s}^{-1}}{20 \text{ s}^{-1}} = 1.5 \text{ cm}$$

Thus, the minimum separation between the consecutive compression of the slinky is 1.5 cm.

- 135.** A bat can hear sound at frequencies up to 120 kHz. Determine the wavelength of sound in the air at this frequency. Take the speed of sound in the air as 344 m/s.

Ans :

Given,

$$\begin{aligned}\text{Frequency, } \nu &= 120 \text{ kHz} \\ &= 120 \times 10^3 \text{ Hz} \\ &= 120 \times 10^3 \text{ s}^{-1}\end{aligned}$$

Velocity of sound in the air, $v = 344$ m/s

Wavelength of the sound wave = λ

We know,

$$\begin{aligned}\text{Wavelength, } \lambda &= \frac{\text{wave velocity}}{\text{frequency}} \\ &= \frac{344 \text{ ms}^{-1}}{120 \times 10^3 \text{ s}^{-1}}\end{aligned}$$

$$= 2.87 \times 10^{-3} \text{ m}$$

$$= 0.29 \text{ cm}$$

- 136.** A gun is fired in the air at a distance of 660 m, from a person. He hears the sound of the gun after 2 s. What is the speed of sound?

Ans :

Given,

Distance travelled by sound = 660 m,

Time taken by the sound = 2 s,

$$\begin{aligned}\text{So, Speed of sound} &= \frac{\text{Distance}}{\text{Time}} \\ &= \frac{660 \text{ m}}{2 \text{ s}} \\ &= 330 \text{ m/s}\end{aligned}$$

Thus, the speed of sound in the air is 330 m/s.

- 137.** A child hears an echo from a cliff 4 seconds after the sound from a powerful cracker is produced. How far away is the cliff from the child? Velocity of sound in air at 20°C is 344 m/s.

Ans :

Let the distance between the child and the cliff be d . Then,

Total distance travelled by the sound = $2d$

Total time taken by the sound = 4 s

$$\text{Then, Velocity of sound} = 344 \text{ m/s} = \frac{d}{2s}$$

$$\begin{aligned}\text{This gives, } d &= 344 \text{ m/s} \times 2 \text{ s} \\ &= 688 \text{ m}\end{aligned}$$

Thus, the cliff is at a distance of 688 m from the child.

- 138.** A ship sends on a high frequency sound wave and receives an echo after 1 second. What is the depth of the sea? Speed of sound in water is 1500 m/s.

Ans :

Let, Depth of the sea = d

So, total distance travelled by the sound wave = $2d$

Time taken by sound to travel both ways = 1s

As per definition,

$$\begin{aligned}\text{Speed of the sound} &= 1500 \text{ ms}^{-1} = \frac{2d}{1s} \\ \text{or } d &= 1500 \text{ ms}^{-1} \times \frac{1s}{2} \\ &= 750 \text{ m}\end{aligned}$$

Thus, the depth of the sea is 750 metres.

- (c) Sound requires a material medium (solid, liquid, or gas) to travel. In outer space, there is a near vacuum and no air or other medium for the sound waves to propagate through, which is why astronauts use special devices to communicate.

160. During a science exhibition, a group of ninth graders set up a long metal slinky on a smooth table. One student pushed and pulled one end of the slinky in quick succession while the other end was held firmly. The visitors observed bands of closely packed coils moving towards the fixed end, followed by regions where the coils were spread far apart. To show that the metal coils themselves were not travelling from one end to the other, a student tied a small red ribbon to one of the middle coils and asked the audience to observe its motion.

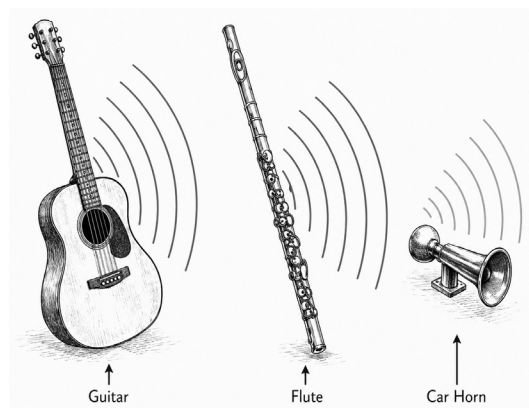
QUESTIONS:

- What do the closely packed coils and the spread-out coils represent in a sound wave travelling through air?
- Describe the motion of the red ribbon as the disturbance passes through the slinky.
- What specific type of wave is demonstrated in this exhibition?
- How does this slinky activity explain the concept that sound is a mechanical wave?

Ans :

- The closely packed coils represent compressions (regions of higher density), and the spread-out coils represent rarefactions (regions of lower density) in a sound wave.
- The red ribbon does not travel to the end of the slinky. It only oscillates back and forth parallel to the direction of the disturbance, about its own position of rest.
- This demonstrates a longitudinal wave, where the particles of the medium vibrate parallel to the direction of wave propagation.
- The activity shows that a disturbance requires a physical material (the slinky) to travel from one point to another. Since sound also requires a material medium to propagate and cannot travel in a vacuum, it is classified as a mechanical wave.

- 161.** Two different musical instruments, say a guitar and a flute, play a note of the same pitch and loudness. However, a listener can easily distinguish between the sounds of the guitar and the flute. Another sound from a car horn has a different pitch compared to the guitar.



- Which characteristic of a sound wave determines its pitch? How is pitch related to frequency?
- Which characteristic of a sound wave determines its loudness? How is loudness related to amplitude?
- If the guitar and flute play the same pitch and loudness, which characteristic of sound helps distinguish between them?
- If the car horn produces a sound of higher pitch than the guitar, what can you say about the frequency of the sound waves produced by the car horn compared to the guitar?

Ans :

- The pitch of a sound wave is determined by its frequency. A higher frequency results in a higher pitch.
- The loudness of a sound wave is determined by its amplitude. A larger amplitude results in a louder sound.
- The quality or timbre of the sound helps distinguish between the sounds of the guitar and the flute, even if they have the same pitch and loudness.
- If the car horn has a higher pitch, its sound waves have a higher frequency compared to the guitar.

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- 144.** Calculate (a) the wavelength (b) the time period of a tuning fork of frequency 512 Hz which is set to vibrate. Velocity of sound in air is 320 m/s.

Ans :

Given,

Frequency of the tuning fork, $\nu = 512$ Hz

Velocity of sound, $v = 320$ m/s

As we know that,

$$\text{Wavelength, } \lambda = \frac{v}{\nu} = \frac{320}{512} = 0.625 \text{ m}$$

$$\text{time period, } t = \frac{1}{\nu} = 0.00195 \text{ s}$$

- 145.** Sound waves travel with a speed of 330 m/s. What is the wavelength of sound, whose frequency is 550 Hz?

Ans :

Given,

Speed of the sound wave, $v = 330$ m/s

Frequency of the sound wave, $\nu = 550$ Hz

$$\text{Wavelength, } \lambda = \frac{v}{\nu} = \frac{330}{550} = \frac{33}{55}$$

$$\text{Wavelength} = 0.6 \text{ m}$$

- 146.** Radiowaves of speed $3 \times 10^8 \text{ ms}^{-1}$ are reflected off the Moon and received back on Earth. The time elapsed between the sending of the signal and receiving it back at the Earth station is 2.5 s. What is the distance of the Moon from the Earth?

Ans :

Given,

Speed of Radio wave, $v = 3 \times 10^8 \text{ m/s}$

Time, $t = 2.55$

As we know that,

$$\begin{aligned} d &= v \times \frac{t}{2} \\ &= \frac{3 \times 10^8 \times 2.5}{2} \\ &= \frac{7.5 \times 10^8}{2} = 3.75 \times 10^8 \text{ m} \end{aligned}$$

- 147.** If the speed of sound in air is 340 m/s, what is the wavelength of sound waves produced by a source vibrating at a frequency of 500 Hz? Would this sound be audible to humans?

Ans :

Given,

Speed of sound $v = 340 \text{ m/s}$.

Frequency $\nu = 500 \text{ Hz}$.

The relationship is $v = \nu \lambda$.

So, wavelength

$$\begin{aligned} \lambda &= \frac{v}{\nu} \\ &= \frac{340 \text{ m/s}}{500 \text{ Hz}} \\ &= \frac{340}{500} \text{ m} = \frac{34}{50} \text{ m} \\ &= 0.68 \text{ metres.} \end{aligned}$$

The wavelength of the sound wave is 0.68 m.

Yes, this sound would be audible to humans because its frequency (500 Hz) falls within the typical human audible range of 20 Hz to 20,000 Hz.

- 148.** (a) A sound wave of wave length 0.33 m has a time period of 10^{-3} s. If the time period is decreased to 10^{-4} s, calculate the wave length and frequency of the new wave.
(b) Name the subjective property of sound related to its frequency and of light related to its wavelength.

Ans :

(a) Wavelength, $\lambda = 0.33 \text{ m}$

Time taken to travel, $t = 10^{-3}$

$$\text{Velocity} = \frac{\lambda}{t} = \frac{0.33}{10^{-3}} = 300 \text{ ms}^{-1}$$

Time period of 2nd wave = 10^{-4} s

Therefore, wavelength, $\lambda = v \times t$

$$= 300 \times 10^{-4} = 0.033 \text{ m}$$

$$\text{Frequency} = \frac{1}{t} = \frac{1}{10^{-3}} = 10^3 \text{ Hz}$$

- (b) Pitch is related to the frequency of sound and colour is related to the wavelength of light.

- 149.** A longitudinal wave of wavelength 1 cm travels in air with a speed of 330 ms^{-1} . Calculate the frequency of the wave. Can this wave be heard by a normal human being?

Ans :

Given,

Wavelength, $\lambda = 1 \text{ cm} = 0.01 \text{ m}$

$$v = \nu \lambda$$

$$\nu = \frac{v}{\lambda} = \frac{330}{0.01} = 33,000 \text{ Hz}$$

The sound is not audible to human ear because frequency 20 to 20,000 Hz is the audible range of human ear.

- 150.** A person standing between two vertical cliffs and 640 m away from the nearest cliff shouted. He heard the 1st echo after 4 seconds and the second echo 3 seconds later. Calculate : (i) the velocity of sound in air and (ii) the distance between the cliff.

Ans :

$$\begin{aligned}\text{Velocity of sound, } v &= \frac{2d}{t} \\ &= \frac{2 \times 640}{4} = 320 \text{ ms}^{-1}\end{aligned}$$

Distance the farthest cliff,

$$\begin{aligned}d &= \frac{v \times t}{2} \\ &= \frac{320 \times 7}{2} = 1120 \text{ m}\end{aligned}$$

Therefore the distance between the cliffs,

$$\begin{aligned}d &= 640 + 1120 \\ &= 1760 \text{ m}\end{aligned}$$

- 151.** A ship on the surface of water sends a signal and receives it back after 4 seconds from a submarine inside the water. Calculate the distance of the submarine from the ship (The speed of sound in water is 1450 ms^{-1}).

Ans :

As we know that,

$$\begin{aligned}v &= \frac{2d}{t} \\ d &= \frac{v \times t}{2} = \frac{1450 \times 4}{2} \\ &= 2900 \text{ m or } 2.9 \text{ km}\end{aligned}$$

- 152.** A man fires a gun and hears its echo after 5 seconds. The man then moves 310 m towards the hill and fires his gun again. This time he hears the echo after 3 seconds. Calculate the speed of sound.

Ans :

Let d be the distance between the man and the hill in the beginning.

$$\begin{aligned}v &= \frac{2d}{t} \\ &= \frac{2d}{5} \quad \dots(1)\end{aligned}$$

He moves 310 m towards the hill. Therefore, the distance will be $(d - 310)$ m.

$$v = \frac{2(d - 310)}{3} \quad \dots(2)$$

Since, velocity of sound is same, equating (1) and (2), we get

$$\frac{2d}{5} = \frac{2(d - 310)}{3}$$

$$3d = 5d - 1550$$

$$2d = 1550$$

$$d = 775 \text{ m}$$

$$\text{Velocity of sound, } v = \frac{2 \times 775}{5} = 310 \text{ ms}^{-1}$$

- 153.** The frequency of a source of sound is 100 Hz. How many times does it vibrate in a minute?

Ans :

No. of vibrations produced in 1 s = 100

$$\begin{aligned}\text{No. of vibrations produced in 60 (sec) = 1 min} \\ &= 100 \times 60 = 6000.\end{aligned}$$

- 154.** A girl claps and hears the echo after reflection from cliff which is 660 m away. If the velocity of sound is 330 ms^{-1} , calculate the time taken for hearing the echo.

Ans :

$$v \times t = 2d$$

$$t = \frac{2d}{v} = \frac{2 \times 660}{330} = 4 \text{ s}$$

- 155.** A longitudinal wave of wavelength 1 cm travels in air with a speed of 330 ms^{-1} . Calculate the frequency of the wave. Can this wave be heard by a normal human being?

Ans :

$$\text{Given} \quad \lambda = 1 \text{ cm} = 0.01 \text{ m}$$

$$v = 330 \text{ ms}^{-1}$$

$$\text{Using} \quad v = \nu \lambda$$

$$\text{We have,} \quad \nu = \frac{v}{\lambda} = \frac{330}{0.01} = 33000 \text{ Hz}$$

No, this cannot be heard by a normal human being.

- 156.** A sound wave has a frequency of 2 kHz and a wavelength of 35 cm. How long will it take to travel 1.5 km?

Ans :

$$\text{Given, Frequency } \nu = 2 \text{ kHz} = 2000 \text{ Hz.}$$

$$\text{Wavelength } \lambda = 35 \text{ cm} = 0.35 \text{ m.}$$

$$\text{Speed of sound} \quad v = \nu \lambda$$

$$= 2000 \text{ Hz} \times 0.35 \text{ m}$$

$$= 700 \text{ m/s.}$$

Distance to travel $d = 1.5\text{km} = 1500\text{m}$.

$$\begin{aligned}\text{Time taken } t &= \frac{\text{distance}}{\text{speed}} = \frac{d}{v} \\ &= \frac{1500\text{m}}{700\text{m/s}} = \frac{15}{7}\text{s} \\ &\approx 2.14\text{seconds.}\end{aligned}$$

It will take approximately 2.14 seconds to travel 1.5 km.

- 157.** A stone is dropped from the top of a tower 500 m high into a pond of water at the base of the tower. When is the splash heard at the top? (Given, $g = 10\text{ ms}^{-2}$ and speed of sound $= 340\text{ ms}^{-1}$).

Ans :

This problem has two parts: the time taken for the stone to fall (t_1) and the time taken for the sound of the splash to travel back to the top (t_2).

Part 1: Time for the stone to fall (t_1)

Height of tower $h = 500\text{m}$.

Initial velocity of stone $u = 0$.

Acceleration $g = 10\text{m/s}^2$.

$$\begin{aligned}\text{Using } s &= ut + \frac{1}{2}at^2 \\ \Rightarrow h &= 0 \cdot t_1 + \frac{1}{2}gt_1^2 \\ 500 &= \frac{1}{2} \times 10 \times t_1^2 \\ 500 &= 5t_1^2 \\ t_1^2 &= \frac{500}{5} = 100 \\ t_1 &= \sqrt{100} = 10\text{seconds.}\end{aligned}$$

Part 2: Time for the sound to travel back (t_2)

Distance for sound to travel = height of tower = 500 m.

Speed of sound $v_{\text{sound}} = 340\text{m/s}$.

$$\begin{aligned}t_2 &= \frac{\text{Distance}}{\text{Speed of sound}} \\ &= \frac{500\text{m}}{340\text{m/s}} = \frac{50}{34}\text{s} = \frac{25}{17}\text{s} \\ &\approx 1.47\text{seconds.}\end{aligned}$$

Total time until splash is heard:

$$\begin{aligned}\text{Total time } T &= t_1 + t_2 \\ &= 10\text{s} + 1.47\text{s} = 11.47\text{s.}\end{aligned}$$

The splash will be heard at the top approximately 11.47 seconds after the stone is dropped.

- 158.** A person clapped his hands near a cliff and heard the echo after 2 seconds. If the speed of sound is taken as 346 m/s , what is the distance of the cliff from the person?

Ans :

Time taken for the echo to be heard $t = 2\text{s}$.

Speed of sound $v = 346\text{m/s}$.

In 2 seconds, the sound travels from the person to the cliff and back to the person.

$$\begin{aligned}\text{Total distance travelled by sound} &= \text{speed} \times \text{time} \\ &= 346\text{m/s} \times 2\text{s} = 692\text{m.}\end{aligned}$$

This total distance is twice the distance (d) of the cliff from the person (to the cliff and back).

$$\text{So, } 2d = 692\text{m.}$$

Distance of the cliff

$$d = \frac{692\text{m}}{2} = 346\text{m.}$$

CASE BASED QUESTIONS

- 159.** Riya and her brother built a toy telephone using two empty tin cans and a long cotton string. When the string was pulled tight, Riya whispered into her can, and her brother heard her clearly in the other room. Curious, they tried the same experiment but let the string hang loose. This time, no sound travelled. Later in school, Riya asked her teacher if they could use this toy in space. The teacher smiled and explained how sound travels and why astronauts need special communication devices during spacewalks instead of just talking to each other.

QUESTIONS:

- Identify the medium of sound propagation when the toy telephone was working successfully.
- Why did the sound fail to reach Riya's brother when the string was hanging loose?
- Based on the teacher's explanation, why would the tin can telephone or direct speech not work in outer space?

Ans :

- When the toy telephone was working, the tightly stretched cotton string acted as the solid medium for sound propagation.
- Sound is produced by vibrations. When the string was loose, it could not vibrate properly or transfer the vibrational energy from one tin can to the other, stopping the propagation of sound.

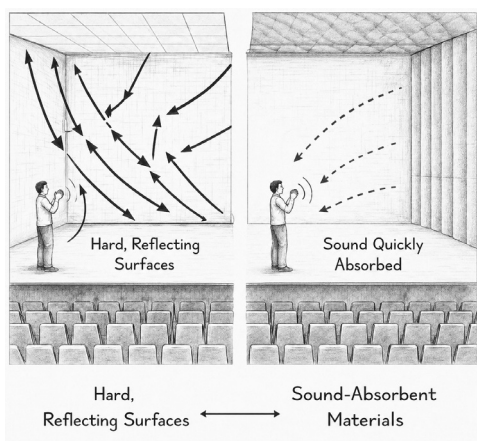
QUESTIONS:

- Why does sound travel faster through the steel railway track than through the surrounding air?
- If the speed of sound in the air is roughly 340 m/s, what happens to the wavelength of the train's sound if it travels through the steel track instead? (Assume frequency remains constant).
- Besides the state of the medium, mention two conditions of the air that can cause the speed of sound travelling through it to increase.

Ans :

- The speed of sound depends on the nature of the medium. Sound travels fastest in solids (like steel) because the particles in a solid are closely packed, allowing vibrations to transfer more rapidly than in gases (like air).
- Since $\text{speed} = \text{wavelength} \times \text{frequency}$ and the frequency remains constant, an increase in the speed of sound (when travelling through steel) will result in a longer (increased) wavelength.
- The speed of sound in air increases with an increase in temperature and an increase in humidity.

- 165.** In a large empty concert hall with hard, reflecting surfaces, a single sharp sound, like a clap, seems to persist for a while. This makes it difficult to hear speech or music clearly. To remedy this, the walls and ceilings are often covered with sound-absorbent materials.



- What is the persistence of sound due to repeated reflections called?
- Why is excessive reverberation undesirable in concert halls or auditoriums?

- Name two types of materials that can be used to reduce reverberation.
- How do these sound-absorbent materials work to reduce reverberation?

Ans :

- The persistence of sound due to repeated reflections is called reverberation.
- Excessive reverberation is undesirable because it causes sounds to overlap and become unclear, making speech and music difficult to understand and appreciate.
- Two types of materials are compressed fibreboard and rough plaster or draperies. Seat materials with sound-absorbing properties are also used.
- Sound-absorbent materials reduce reverberation by absorbing most of the sound energy that falls on them, rather than reflecting it. This reduces the number and intensity of reflections, causing the sound to die out more quickly.

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166. At the community center, a choir director was auditioning students for a play. He noticed that Rahul, who used to sing high-pitched notes effortlessly last year, now had a deep, rumbling voice. When Rahul tried to sing loudly to reach the high notes, his voice cracked. The director gently explained that as boys grow, their vocal cords undergo physical changes, making them thicker and longer. He advised Rahul to practice controlling the volume of his singing instead of forcing the pitch, explaining that these two aspects of sound depend on completely different wave properties.

QUESTIONS:

- How does the thickening and lengthening of Rahul's vocal cords affect the frequency of the sound he produces?
- What physical property of a sound wave determines the loudness that the choir director told Rahul to control?
- Differentiate between pitch and loudness based on the physical properties of the sound wave they depend upon.
- Does a louder sound wave carry more or less energy than a softer sound wave? Justify your answer.

162. A music teacher was helping her students tune their instruments using a new mobile application. When a student struck the tuning fork for the 'Sa' note, the app displayed a simple wave graph with peaks and valleys on the screen. The teacher then asked another student to play a higher musical note on the flute. The new graph on the screen looked different, with the peaks appearing much closer together. The teacher explained that every musical note has a unique physical characteristic that determines how our ears perceive it, and this app visually captures those differences.

QUESTIONS:

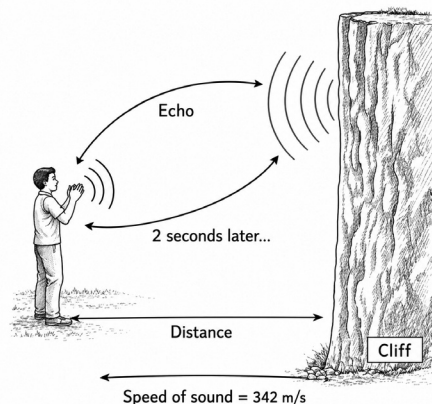
- What are the highest points (peaks) and lowest points (valleys) of the sound wave graph called?
- Which physical quantity of the sound wave changed to make the peaks appear much closer together when the higher note was played?
- How is the physical quantity identified in (b) mathematically related to the time period of the wave?
- What subjective human perception of sound corresponds to this physical characteristic that changed with the higher note?
- If the first tuning fork produces 500 complete density oscillations in 2 seconds, calculate its frequency.

Ans :

- The highest points of the wave graph are called crests, and the lowest points are called troughs.
 - The wavelength of the sound wave decreased, which means the frequency of the sound wave increased when the higher note was played.
 - Frequency and time period are inversely related.
- Frequency = $1 / \text{Time period}$.
- The human perception of frequency is called pitch. A higher frequency is perceived as a higher pitch.
 - Frequency is the number of oscillations per unit time.

$$\begin{aligned} \text{Frequency} &= 500 \text{ oscillations} / 2 \text{ seconds} \\ &= 250 \text{ Hz.} \end{aligned}$$

163. A person stands some distance away from a tall cliff and claps loudly. They hear the clap again a few seconds later. The speed of sound in air on that day is 340m/s. The person hears the echo 2 seconds after clapping.



- What is the phenomenon of hearing the sound again called?
- What is the minimum time interval required between the original sound and the reflected sound for a distinct echo to be heard by the human ear?
- What is the total distance travelled by the sound wave from the person to the cliff and back to the person?
- Calculate the distance of the cliff from the person.

Ans :

- This phenomenon is called an echo.
- The minimum time interval required is at least 0.1 seconds.
- Total distance = speed of sound $\times$ time taken for echo = $340\text{m/s} \times 2\text{s} = 680\text{m}$.
- The distance of the cliff from the person is half of the total distance travelled by the sound, so Distance = $\frac{680\text{m}}{2} = 340\text{m}$.

164. While visiting a rural village, Aryan walked past an old, unused railway track. A local farmer told him a story about how, in the old days, villagers would press their ears against the steel rails to know if a train was approaching from miles away, long before they could hear it through the air. The farmer claimed that the metal tracks delivered the sound much faster and clearer. Aryan wondered why the sound of the same train would behave differently depending on whether he was listening through the air or through the solid metal track.

- 139.** A sonar echo takes 2.2 s to return from a whale. How far away is the whale?

Ans :

Total time taken by the signal = 2.2 s

So,

time taken the signal to reach the whale = 1.1 s

Distance of the whale = d (assume)

Speed of sound in sea water at 25°C = 1533 ms⁻¹

So, distance of the whale,

$$d = \text{Speed of the signal} \times \text{Time taken}$$

$$\text{or } d = 1533 \text{ ms}^{-1} \times 1.1 \text{ s}$$

$$= 1686.3 \text{ m}$$

- 140.** Using the SONAR, sound pulses are emitted at the surface of water. These pulses after being reflected from the bottom are detected. If the time interval from the emission to the detection of the sound pulses is 2 seconds, find the depth of the water. Velocity of sound in water = 1498 m/s.

Ans :

Let, depth of the water from the Earth's surface be d. Then,

Total distance travelled by the pulse = 2d

Total time taken by the pulse = 2s

As per definition,

$$\text{Velocity} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

$$\text{So, Velocity of the sound} = \frac{2d}{2s} = \frac{d}{s}$$

$$1498 \text{ m/s} = \frac{d}{s}$$

$$\begin{aligned} \text{This gives, } d &= 1498 \text{ m/s} \times 1 \text{ s} \\ &= 1498 \text{ m} \end{aligned}$$

Thus, the depth of water is 1498 m.

- 141.** A wave moves a distance of 8 m in 0.05 s :
- Find the velocity of the wave.
 - What is the wavelength of the wave if its frequency is 200 Hz?

Ans :

$$\begin{aligned} \text{(a) Velocity} &= \frac{8}{0.05} \\ &= 160 \text{ ms}^{-1} \end{aligned}$$

$$\begin{aligned} \text{(b) } \lambda &= \frac{160}{200} \\ &= 0.8 \text{ m} \end{aligned}$$

- 142.** A stone is dropped into a well 44.1 m deep. The splash is heard 3.13 seconds after the stone is dropped. Find the velocity of sound in air.

Ans :

Stone falling from A to B

Here, u = 0, s = 44.1 m, g = 9.8 ms⁻², t = ?

As we know that,

$$s = ut + \frac{1}{2} gt^2$$

$$44.1 = \frac{1}{2} \times 9.8 \times t^2$$

$$t = 3 \text{ s}$$

Sound produced at B, due to sound produced by the stone falling on the surface of water, travels from B to A. The sound moves with constant velocity.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$v = \frac{44.1}{t'}$$

$$t' = \frac{44.1}{v} \quad \dots(1)$$

It is given that the total time is 3.13 second.

$$\text{i.e. } t + t' = 3.13$$

From eqⁿ (1), we get

$$3 + \frac{44.1}{v} = 3.13$$

$$\frac{44.1}{v} = 0.13$$

$$v = 339.2 \text{ ms}^{-1}$$

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- 143.** Using sonar, sound pulses are emitted at the surface of water. These pulses after being reflected from water bottom are detected. If the time interval from the emission to the detection of the sound pulses is 2 seconds, find the depth of the water. (Speed of sound in water = 1531 m/s given)

Ans :

Given, Time, t = 2 s

As we know that,

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$1531 = \frac{2x}{2}$$

$$x = 1531 \text{ m}$$

Ans :

- The thickening and lengthening of the vocal cords cause them to vibrate less frequently, which decreases the frequency of the sound, resulting in a deeper, lower-pitched voice.
- Loudness is determined by the amplitude of the sound wave.
- Pitch is the human perception of a sound wave's frequency, whereas loudness is the human perception of a sound wave's amplitude.
- A louder sound wave carries more energy. This is because a larger amplitude means the source was struck harder, transferring more energy to the medium's particles and causing larger displacements.

167. During a school trekking trip in the mountains, Neha stood facing a tall, steep cliff. She shouted her name loudly and was thrilled to hear her name bounce back to her a few seconds later. Her friend Aman tried to do the same inside their small hotel room, but he only heard his original voice and no returning sound, even though the room had hard walls. The guide explained that for the brain to distinguish the original sound from the reflected sound, there must be a specific minimum distance between the speaker and the reflecting surface.

QUESTIONS:

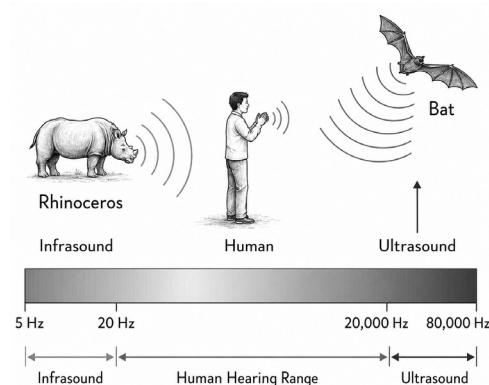
- What is the scientific term for the reflection of sound that Neha heard in the mountains?
- Why couldn't Aman hear a distinct reflected sound in the small hotel room?
- What is the minimum time interval required for the human ear to clearly distinguish between an original sound and its reflection?
- If Neha heard her reflected voice exactly 2 seconds after shouting, calculate the distance between her and the cliff. (Assume the speed of sound in air is 340 m/s).

Ans :

- The distinct reflection of sound heard after the original sound has stopped is called an echo.
- In a small room, the walls are too close, so the reflected sound reaches the ear in less than 0.1 seconds. The brain cannot separate it from the original sound, so no distinct echo is heard.
- The minimum time interval required to clearly distinguish the original sound from the reflected sound is 0.1 seconds.

- Distance travelled by sound = speed $\times$ time
 $= 340 \text{ m/s} \times 2 \text{ s} = 680 \text{ m}$. Since this is the total distance to the cliff and back, the distance between Neha and the cliff is half of this, which is $680 / 2 = 340 \text{ meters}$.

168. Humans can typically hear sounds with frequencies ranging from 20 Hz to 20,000 Hz. Rhinoceroses communicate using sounds with frequencies as low as 5 Hz, while bats use sounds with frequencies much higher than 20,000 Hz for navigation and hunting.



- What is the audible range of frequency for human beings?
- What are sounds with frequencies below 20 Hz called? Give an example of an animal that uses such sounds.
- What are sounds with frequencies above 20,000 Hz called? Give an example of an animal that uses such sounds.
- Can humans hear the sounds produced by rhinoceroses for communication or the navigational sounds of bats? Why or why not?

Ans :

- The audible range for human beings is from about 20 Hz to 20,000 Hz.
- Sounds with frequencies below 20 Hz are called infrasonic sound or infrasound. Rhinoceroses use infrasound (e.g., at 5 Hz).
- Sounds with frequencies above 20,000 Hz are called ultrasonic sound or ultrasound. Bats produce ultrasound.
- No, humans cannot hear these sounds because their frequencies lie outside the human audible range. Infrasound is below 20 Hz, and ultrasound is above 20,000 Hz.

- 169.** A town recently built a large, beautiful community hall with smooth concrete walls and a flat ceiling. However, during the first public speech, the audience complained that the speaker's words were completely garbled and echoed continuously, making it impossible to understand anything. An acoustic engineer was called to fix the issue. She observed the hall and immediately recommended covering the walls with thick, soft curtains, installing upholstered chairs, and redesigning the ceiling to be curved rather than flat. The renovations drastically improved the audio quality for the next event.

QUESTIONS:

- What is the specific term for the phenomenon that caused the garbled and continuously persisting sound in the community hall?
- Why did the acoustic engineer recommend installing thick curtains and upholstered chairs?
- How does a curved design on ceilings help improve the quality of sound for the audience compared to flat surfaces?

Ans :

- The persistence of sound due to multiple reflections from the walls and ceiling is called reverberation.
- Thick curtains and upholstered chairs act as sound-absorbing materials. They absorb the unwanted sound reflections, thereby reducing reverberation and making speech clear.
- A curved ceiling acts like a soundboard. It reflects sound waves uniformly across the entire hall, ensuring that sound reaches all parts of the audience clearly, whereas flat surfaces might scatter sound unevenly or cause direct echoes.

- 170.** Mr. Sharma was experiencing severe abdominal pain and visited the hospital. The doctor suspected kidney stones and sent him for an imaging scan. The technician used a device that emitted high-frequency sound waves, completely inaudible to the human ear, to create a picture of his internal organs on a monitor. The scan confirmed the presence of a small stone. To avoid surgery, the doctor suggested a treatment where similar, highly concentrated sound waves would be directed at the stone to shatter it into tiny grains, which could then naturally pass out of his body.

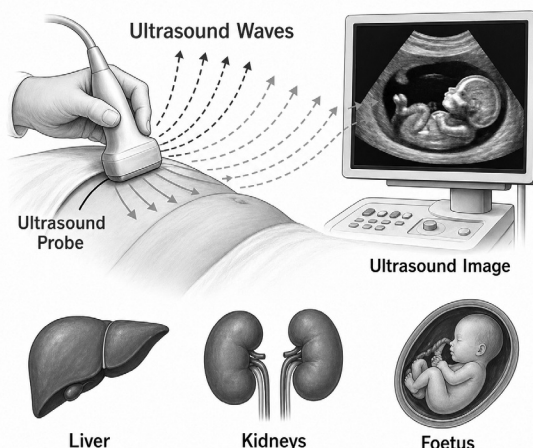
QUESTIONS:

- What term is used for the high-frequency sound waves that are inaudible to the human ear used in Mr. Sharma's scan?
- What is the frequency range of the sound waves being used in this medical device?
- Why are humans unable to hear the sound waves being emitted by this imaging device?
- Mention one industrial application of this specific type of sound wave.
- Can these same high-frequency waves be detected by any animals? Give one example.

Ans :

- The high-frequency sound waves are called ultrasonic waves (or ultrasound).
- Ultrasonic waves have a frequency greater than 20,000 Hz (or 20 kHz).
- Humans cannot hear them because the human audible range is limited to frequencies between 20 Hz and 20,000 Hz. Waves above this limit cannot be detected by the human ear.
- In industries, ultrasonic waves are used for cleaning delicate machine parts or detecting flaws and cracks in metal blocks.
- Yes, some animals can detect these high-frequency waves. Examples include dogs, cats, bats, and dolphins.

- 171.** Doctors often use a technique called ultrasonography to get images of internal organs like the liver, kidneys, or a developing foetus in the womb. This technique involves sending high-frequency sound waves into the body and detecting the reflected waves.



1. What type of sound waves are used in ultrasonography?
2. How are images of internal organs formed using this technique?
3. Mention one specific use of ultrasonography during pregnancy.
4. Why can ordinary sound waves not be used effectively for such detailed imaging purposes as effectively as ultrasound?

Ans :

1. Ultrasonic waves (ultrasound) are used in ultrasonography.
2. Ultrasonic waves travel through the body tissues and get reflected from regions where there is a change in tissue density. These reflected waves are then converted into electrical signals, which are used to generate images of the organ.
3. Ultrasonography is used for the examination of the foetus during pregnancy to detect congenital defects and growth abnormalities.
4. Ordinary sound waves have longer wavelengths and tend to bend around small obstacles (like internal structures or defects). Ultrasounds have very high frequencies and short wavelengths, allowing them to travel along well-defined paths and reflect off smaller structures, providing more detailed images.

- 112.** A research ship was on a mission to map the ocean floor and locate an old sunken vessel. The captain activated a sophisticated device at the bottom of the ship that sent out rapid bursts of sound into the deep seawater. The crew watched the computer screens carefully, measuring the exact time it took for the signals to travel down, hit the ocean floor or the sunken object, and bounce back to the ship's receiver. Using these time measurements and the known properties of seawater, the computer calculated the exact depth of the wreck.

QUESTIONS:

- (a) What is the name of the technique and device used by the research ship to locate the sunken vessel?
- (b) Do the sound waves emitted by this device travel faster in the air above the ship or in the seawater below it? Give a reason.
- (c) Name two animals that use a similar natural principle for navigation and hunting in the dark.

- (d) If the sound signal returns to the ship after 4 seconds and the speed of sound in seawater is 1530 m/s, calculate the depth of the ocean floor.

Ans :

- (a) The device is called SONAR (Sound Navigation and Ranging), and the technique is based on echolocation or reflection of sound.
- (b) The sound waves travel faster in seawater (a liquid) than in air (a gas) because the particles in liquids are closer together than in gases, allowing for faster propagation of the sound wave.
- (c) Bats and dolphins (or whales) use a similar natural principle called echolocation.
- (d) Total time taken for the signal to go down and come back = 4 s.

Time taken to reach the ocean floor

$$= 4 / 2 = 2 \text{ s.}$$

Depth = speed $\times$ time

$$= 1530 \text{ m/s} \times 2 \text{ s}$$

$$= 3060 \text{ meters.}$$

- 113.** Priya loves listening to rock music on her earphones at the maximum volume. During a routine school health check-up, the doctor conducted an audiogram test and noticed a slight decrease in Priya's hearing sensitivity. The doctor explained that sound is a form of energy. When highly energetic sound waves constantly hit the delicate thin membrane inside the ear, it can cause long-term damage. The doctor strongly advised Priya to lower the volume, explaining that everyday conversations are around 60 decibels, but earphones at maximum volume push dangerous limits that the human ear shouldn't endure for long.

QUESTIONS:

- (a) Name the thin membrane inside Priya's ear that vibrates when sound energy enters it.
- (b) What is the physical quantity defined as the amount of sound energy passing through a unit area per second, which corresponds to the high decibels the doctor warned about?
- (c) How does the amplitude of the sound wave change when Priya reduces the volume of her music, and how does this action protect her ears?

Ans :

- (a) The thin membrane inside the ear is called the eardrum.
- (b) The amount of sound energy passing through a unit area perpendicular to the direction of propagation in one second is called the intensity of sound.
- (c) When Priya reduces the volume, the amplitude of the sound waves decreases. A smaller amplitude means less energy is transferred by the wave, which reduces the forceful vibrations on her eardrum, thereby protecting it from damage.

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CHAPTER 11

Reproduction: How Life Continues

SUMMARY

1. ASEXUAL REPRODUCTION

Asexual reproduction involves only one parent and produces genetically identical individuals called clones. It is seen in unicellular organisms like bacteria, amoeba, and yeast. It is also seen in simple multicellular organisms like hydra and sponge. Many plants sprout new shoots and roots from existing vegetative parts without producing seeds. Plants with fleshy underground stems like potato and ginger grow new plants this way. Sugarcane and money plant stem cuttings grow into new plants. Bryophyllum leaves sprout tiny plantlets that grow into new plants. This method of growing new plants from vegetative parts is called vegetative propagation. The central process behind asexual reproduction is a type of cell division called mitosis.

1.1 How is vegetative propagation in plants helpful in agriculture?

Scientists and horticulturists use asexual reproduction to develop methods for growing plants on a large scale. Cutting involves taking a stem piece with nodes and planting it in soil mixed with compost at an angle. Grafting involves taking a stem piece from one plant and inserting it into a slit on a healthy rooted plant so they grow together. Layering involves burying the middle part of a flexible twig in soil until roots develop, after which it is cut from the parent plant. Tissue culture involves taking the apical meristem or shoot tip of a plant and growing it into healthy plantlets in a glass jar. Tissue culture helps eliminate virus-infected plants and ensures high yields. Yeast reproduces through budding where repeated cell division produces a small outgrowth called a bud that separates to live independently. Hydra also reproduces by budding.

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Fungi or moulds reproduce through spore formation. Spores are tiny, lightweight, single-celled structures formed in a sac-like structure or on a swollen vesicle on fungal hyphae. Spores float in the air and germinate quickly when they find warmth and moisture. Louis Pasteur proved that new life always comes from preexisting life, which helped form the germ theory of disease. Fungi are beneficial as they degrade organic waste and produce antibiotics like penicillin and amoxicillin.

2. SEXUAL REPRODUCTION

Sexual reproduction involves two parents contributing genetic material to form a new individual. It involves a special type of cell division known as meiosis to prevent the chromosome number from doubling in every generation.

2.1 How does meiosis help create variations in sexual reproduction?

Chromosomes are thread-like structures in the nucleus that carry genetic information. Humans have a total of 46 chromosomes which exist as 23 pairs. Meiosis is a special cell division that reduces the diploid parent cell chromosome number to half to form haploid gametes. Male gametes are called sperm in animals and pollen grains in plants. Female gametes are called eggs in animals and are found inside ovules in plants. Every human gamete receives exactly 23 chromosomes. Random mixing of chromosomes during meiosis creates unique combinations. This makes offspring genetically different from their parents and siblings. This variation helps species adapt to changing environments and survive.

2.2 Sexual reproduction in flowering plants

Flowering plants are called angiosperms and their flowers serve as reproductive organs. Sepals form the outermost green whorl that protects the flower in the bud stage. Petals are the coloured

projections that attract pollinators. The stamen is the male part of the flower. The stamen consists of a filament and an anther which produces pollen grains containing male gametes. The pistil is the female part of the flower. The pistil has three subparts called the stigma, style, and ovary. The stigma is located at the tip and is flat or sticky to receive pollen. The style is a long tube connecting the stigma to the ovary. The ovary is the swollen base containing ovules, and each ovule has an egg cell.

2.3 How does the process of pollination occur in flowers?

Pollination is the transfer of pollen grains from the anther to the stigma of a flower. Self-pollination happens when pollen is transferred to the stigma of the same flower or another flower of the same plant. Cross-pollination happens when pollen is transferred to the stigma of a flower of another plant of the same type. Transfer of pollen is essential for the formation of fruits and seeds.

2.4 Pollination strategies and reproductive success

Pollination depends on external agents called pollinators such as wind, water, insects, and birds. Wind pollination is seen in wheat, maize, and rice. Wind-pollinated plants produce large numbers of light and small pollen grains, and have long feathery stigmas to trap them. Water pollination is seen in aquatic plants like Vallisneria and Hydrilla where water currents carry pollen. Insect pollination is seen in sunflower, hibiscus, and marigold. Insect-pollinated flowers are brightly coloured, produce nectar, have fragrance, and have sticky or spiny pollen grains. Bird pollination is seen in coral tree and hibiscus plants.

2.5 Fertilisation and seed formation

After pollen reaches a compatible stigma, it produces a pollen tube that grows down through the style into the ovary. The male gamete moves through this tube to the ovule and fuses with the egg cell. The fusion of male and female gametes is called fertilisation. Fertilisation produces a new cell called a zygote. The zygote develops into an embryo. The ovary enlarges and develops into a fruit. The ovules develop into seeds inside the fruit. Seeds are dispersed by wind, water, and animals, and they germinate into new plants under favourable conditions of water, air, and

temperature. P. Maheshwari is known as the Father of Indian Plant Embryology and developed the technique of in-vitro fertilisation in flowering plants.

3. SEXUAL REPRODUCTION IN ANIMALS

Fertilisation can occur outside or inside the body of the animal. External fertilisation occurs when eggs and sperm are released in water and fertilisation takes place outside the body. External fertilisation is seen in frogs and most fish. Animals with external fertilisation produce a large number of eggs because many are destroyed by water currents or predators. Internal fertilisation occurs when fertilisation takes place inside the body of the female. Internal fertilisation is seen in reptiles, birds, and mammals. Internal fertilisation provides higher chances of survival for the young ones because the fertilised egg or embryo is protected.

4. VARIATIONS IN REPRODUCTION IN ANIMALS

Animals must ensure that male and female gametes meet and that young ones survive long enough to grow. Fish, amphibians, and insects produce thousands of eggs containing just enough yolk to produce a larva. The larva hatches, eats organic waste, and eventually transforms into an adult body like a butterfly or frog. Reptiles and birds lay eggs containing enough yolk to nourish the developing embryo until it hatches. Mammals are different because the zygote grows and develops inside the female body. After birth, mammals feed their young ones via breast milk for some duration.

5. REPRODUCTION IN HUMAN BEINGS

Reproduction happens when special organs mature and produce gametes, allowing a sperm and egg to fuse and form a new life.

5.1 Reproductive maturity

Children grow into adults and undergo physical and emotional changes. The reproductive organs mature and begin producing sperm in males and eggs in females. When a sperm meets an egg inside the female body, they form a zygote that develops into an embryo and eventually a foetus.

5.2 What are the parts of the male reproductive system?

The male reproductive system produces sperm and transfers them to the female body. Sperm are produced in two oval-shaped organs called testes. The testes are present in a pouch of skin called the scrotum which keeps them slightly cooler than normal body temperature. Testes also produce hormones that regulate sperm production and cause physical changes in boys during puberty. Sperm travel from the testes through a long tube called the vas deferens. The vas deferens opens into the urethra, which is a common passage for urine and sperm. The seminal vesicles and prostate gland add fluids to nourish the sperm and help them swim. Each sperm has a head containing genetic material and a long tail for movement.

5.3 What are the parts of the female reproductive system?

The female reproductive system consists of a pair of ovaries, oviducts or fallopian tubes, a uterus, and a vagina. Ovaries produce female germ cells called eggs and also release hormones. Hormones bring about changes during puberty. The oviducts connect each ovary to the uterus. The uterus is a bag-like structure where a foetus develops. The uterus opens into the vagina through a narrow passage called the cervix.

5.4 How are reproductive cells made?

Gametogenesis is the process of gamete formation that takes place in the testes and ovaries. Gametes are formed by meiosis which reduces the chromosome number to half. Human sperm and eggs have 23 chromosomes each so that the resulting zygote has 46 chromosomes. Males produce millions of tiny and actively motile sperm. Females produce a few large and non-motile eggs that contain stored nutrients.

5.5 What happens when a sperm meets an egg?

A girl is born with millions of immature eggs in her ovaries. Ovulation is the process where one mature egg is released from one of the ovaries every month from puberty onwards. The inner lining of the uterus becomes thick to prepare for a possible pregnancy. During sexual intercourse, millions of sperm enter through the vagina and swim to the oviduct. Fertilisation happens in the oviduct if a sperm successfully fuses with the egg

to form a zygote. The zygote undergoes mitotic divisions while travelling to the uterus. The zygote implants into the thick, blood-rich inner lining of the uterus for nourishment. Implantation marks the beginning of pregnancy. Subhash Mukhopadhyay pioneered India's first test tube baby using In-vitro Fertilisation techniques.

6. WHAT HAPPENS WHEN AN EGG IS NOT FERTILISED?

An unfertilised egg degenerates after a day. The thick and blood-rich inner lining of the uterus is no longer needed so it breaks down. The lining and blood leave the body through the vagina in a process called menstruation. The menstrual cycle takes 21 to 35 days and repeats usually every 28 days. Menstruation begins at puberty between the ages of 10 and 14 in girls. Menstruation continues until menopause which occurs around age 50. Biological sex is determined by sex chromosomes, where females have XX and males have XY. The mother always contributes an X chromosome, while the father contributes either an X to make a female or a Y to make a male. Good hygiene during menstruation includes using clean pads, washing hands, and proper disposal of used products.

7. PREGNANCY AND CHILDBIRTH

Human pregnancy lasts about nine months and is divided into three trimesters. The fertilised egg develops into an embryo during the first two months. From the ninth week, the developing embryo is called a foetus because major organs start forming. The foetus grows rapidly and the mother can feel its movements in the second trimester. The baby gets ready for life outside the womb in the third trimester. During childbirth, strong contractions of the uterus muscles push the foetus out through the birth canal. Doctors may use surgical procedures if a normal vaginal birth is not safe. Breast feeding provides complete nutrition and protects the infant from many diseases.

7.1 Mother's health during pregnancy

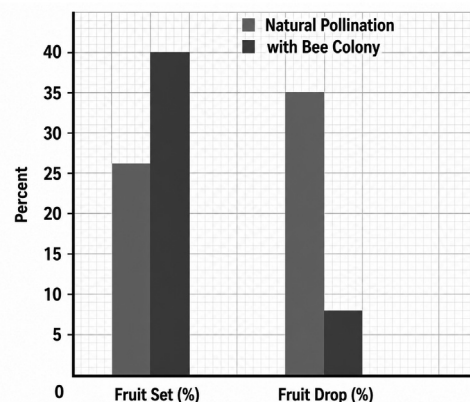
A pregnant woman needs a balanced diet rich in proteins, vitamins, and minerals. She should attend regular medical check-ups and get advice on light exercise and rest. She should avoid harmful substances like alcohol, smoking, and medicines

Ans :

Plant	Type of Pollination	Explanation
Tomato	Self-pollination	Because the stamens closely cover and enclose the stigma, pollen grains naturally fall directly onto the receptive stigma of the same flower before external pollen can easily reach it.
Wheat	Self-pollination	Since the flowers complete pollination before opening, there is no chance for wind or insects to bring pollen from other plants, ensuring self-fertilisation.
Papaya	Cross-pollination	Male and female flowers are on separate trees, so pollen must be transferred by external agents like wind or insects.

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12. In the lower Himalayan region of northern India, apples are an important cash crop that contribute significantly to farmer's livelihoods. The fruit yield in apple cultivation is declining continuously, associated with climate change and a significant decline in the population of natural pollinators. A researcher-farmer group set up two experimental apple orchards at two distinct locations: Places A and B. In apple orchards at Place A, they allowed natural pollinators to pollinate the flowers of the apple. In apple orchards at Place B, they applied mixed farming techniques of beekeeping. Along with honey, the farmer yielded apples. The yield of apples is depicted in figure in terms of fruit setting (number of fruits/the total number of corresponding fruit-bearing branches) and fruit drop (premature falling of developing fruits) in the two types of experimental places of apple orchards.



- What are the hypotheses the researcher-farmers group has thought of for this investigation?
- What are the different parameters in the experiment?
- Compare and analyse the data of two experimental orchards Places A and B, in terms of high yields of apple fruits.
- Based on your analysis, what do you infer from the data?

Ans :

- The primary hypothesis is that introducing artificial bee colonies to the orchards will compensate for the declining natural pollinators, significantly improving pollination efficiency, which will in turn increase the percentage of successful fruit setting and reduce the rate of premature fruit drop compared to relying on natural pollination alone.
- The independent parameter (the variable being manipulated) is the method of pollination, specifically the presence or absence of introduced bee colonies. The dependent parameters (the variables being measured) are the percentage of fruit setting and the percentage of fruit drop. Controlled parameters would inherently include the species of apple trees, geographical and climatic conditions of the lower Himalayan region, and basic agricultural practices applied to both orchards.
- By analysing the provided bar graph, Orchard B, which utilized bee colonies, demonstrated a highly successful fruit set of 40% alongside a remarkably low premature fruit drop of just 5%. In stark contrast, Orchard A, which relied solely on declining natural pollinators, showed

4. Why do animals with external fertilisation generally produce more eggs than animals with internal fertilisation?

Ans :

Animals with external fertilisation release their eggs into open environments, such as water, where they are highly vulnerable. In this unprotected space, a massive number of eggs are destroyed by harsh environmental conditions, washed away by currents, or eaten by predators before they can be fertilised or develop. Therefore, producing a very large quantity of eggs is a biological strategy to ensure that at least a small fraction will successfully survive, undergo fertilisation, and grow into adult organisms.

5. In animals, which fertilisation method the gametes are more protected?

Ans :

Gametes are highly protected during internal fertilisation. This is because the fusion of the sperm and egg, as well as the initial development of the embryo, occurs safely inside the female body.

6. Ravi suddenly notices that he is growing taller rapidly, his shoulders are broadening, and his voice cracks. What stage of life is he entering?

Ans :

Ravi is entering the stage of adolescence and is specifically experiencing the physical changes associated with puberty. During this phase, his reproductive organs are maturing and his body is becoming capable of reproduction.

7. Rina's period occurs every 28 days. Her last period was on the 5th of March. On which day is she most likely to get her next period?

Ans :

Rina is most likely to get her next period on the 2nd of April. This is predicted by adding her typical 28-day menstrual cycle length to the start date of her previous period on March 5th, accounting for the 31 days in the month of March.

8. A human zygote has just formed. How many chromosomes does it have?

Ans :

A newly formed human zygote has exactly 46 chromosomes. It receives 23 chromosomes from

the male sperm and 23 chromosomes from the female egg during the process of fertilisation.

9. What protective devices can be used during sexual activity to reduce the spread of STIs?

Ans :

Barrier methods such as condoms are the primary protective devices used during sexual activity to effectively block the transmission of sexually transmitted infections.

10. If a couple uses oral contraceptive pills but not condoms, which risks remain and why?

Ans :

If a couple uses oral contraceptive pills without condoms, they remain at a high risk of contracting and spreading sexually transmitted infections (STIs). Oral pills work internally by altering hormone levels to prevent the release of eggs, which effectively reduces the risk of unwanted pregnancy but offers zero physical protection. Because there is no physical barrier in place, the exchange of bodily fluids during close sexual contact can still easily transmit infections like HIV, syphilis, and gonorrhoea.

11. In many animals, the young ones can walk or find food soon after birth but human babies are completely dependent for a long time. What might be some advantages and disadvantages of this for humans as a species?

Ans :

A clear disadvantage of this long dependency is that human infants are incredibly vulnerable to environmental dangers and demand immense, constant resources and protection from their parents just to survive. However, the primary advantage is that this extended developmental period allows for the gradual growth of a highly complex human brain outside the womb. This long childhood provides the necessary time for extensive learning, skill acquisition, and emotional maturation, which ultimately enables humans to build advanced and adaptable societies.

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NCERT EXERCISE

1. A flower's anthers are removed before it matures. Later, pollen from another plant of the same species is dusted onto its stigma and seeds are produced. Which process has been ensured here?
 - (i) Self-pollination
 - (ii) Cross-pollination
 - (iii) Fertilisation
 - (iv) Tissue culture

Ans :

Option (ii) Cross-pollination is correct.

By deliberately removing the anthers, self-pollination is physically prevented. Dusting the stigma with pollen from a completely different plant of the same species ensures that cross-pollination takes place, leading to subsequent seed production.

2. Arrange the following stages of sexual reproduction in plants in the correct order:
 - (i) Pollen germination on stigma
 - (ii) Fertilisation
 - (iii) Pollination
 - (iv) Formation of zygote

Ans :

The correct chronological order of stages is:

- (iii) Pollination, followed by
- (i) Pollen germination on stigma, then
- (ii) Fertilisation, and finally
- (iv) Formation of zygote.

3. **Assertion (A):** The zygote formed after fertilisation immediately attaches to the uterus wall.
Reason (R): The uterus wall is always prepared to receive the zygote.
 - (i) Both A and R are true, and R is the correct explanation of A.
 - (ii) Both A and R are true, but R is not the correct explanation of A.
 - (iii) A is true, but R is false.
 - (iv) A is false, but R is true.

Ans :

Option (iv) A is false, but R is true is the most appropriate choice based on standard conventions, though with a caveat. The assertion is false because the zygote does not attach immediately; it undergoes a series of mitotic divisions while travelling through the oviduct before eventually implanting in the uterus. The reason is considered

practically true in the context of the female reproductive cycle, as the inner lining of the uterus cyclically rebuilds and thickens with blood vessels every month specifically to prepare for receiving and nourishing a potential zygote.

Why does asexual reproduction produce offsprings that are genetically identical to the parent?

Ans :

Asexual reproduction involves only a single parent and relies on mitosis, a type of cell division that produces daughter cells with the exact same genetic material and chromosome number as the parent cell. Because there is no involvement of meiosis, no formation of gametes, and no mixing of genetic traits from a second parent, the resulting offspring inherit all their characteristics exclusively from the single parent. This lack of genetic mixing results in the production of clones, which are genetically identical to the parent organism.

5. Explain why the menstrual cycle stops during pregnancy.

Ans :

The menstrual cycle is driven by the monthly preparation of the uterine lining to receive a fertilised egg; if no fertilisation happens, this lining breaks down and sheds as menstrual bleeding. However, when a woman becomes pregnant, a fertilised egg (zygote) successfully implants into the thickened inner lining of the uterus. To support the developing embryo, the body maintains and further enriches this uterine lining with blood vessels for nourishment and protection throughout the nine months of gestation, thereby preventing the shedding process and temporarily halting the menstrual cycle.

6. Why are flowers that bloom at night white or light in colour as compared to flowers that bloom during the day?

Ans :

Flowers that bloom during the day are usually brightly coloured to attract diurnal pollinators like bees, butterflies, and sunbirds, which rely heavily on visual cues and bright colours to find nectar. In contrast, flowers that bloom at night rely on nocturnal pollinators such as moths and bats, which operate in low-light conditions. To attract these night-time pollinators, night-

blooming flowers are predominantly white or light-coloured so they can effectively reflect moonlight and stand out in the dark, often accompanied by strong fragrances to help pollinators locate them.

7. Why do vegetatively propagated plants tend to be more vulnerable to diseases than sexually reproduced plants?

Ans :

Vegetatively propagated plants are produced asexually from the vegetative parts of a single parent plant, which means all the offspring are genetically identical clones of the parent. Because there is absolutely no genetic variation or mixing of new traits within this population, they share the exact same vulnerabilities. If a specific virus, bacteria, or fungus successfully infects one plant, the entire genetically identical crop will be equally susceptible and can be rapidly wiped out, unlike sexually reproduced plants where genetic diversity allows some individuals to naturally resist diseases.

8. If all flowers in a type of plant were only capable of self-pollination, how would it affect the genetic diversity over several generations? Explain.

Ans :

If a plant species were strictly limited to self-pollination, its genetic diversity would drastically decrease over several generations. Self-pollination restricts the transfer of pollen to the same flower or another flower on the exact same plant, preventing the introduction and mixing of new genetic combinations that normally occur when two different plants cross-pollinate. Over time, this inbreeding leads to offspring that are highly genetically similar, severely reducing the plant population's ability to adapt to environmental changes, survive new diseases, or undergo evolutionary progress.

9. A farmer wants to produce a large number of genetically identical plants quickly. Suggest suitable reproduction methods and explain why they are effective.

Ans :

The farmer should utilize artificial methods of vegetative propagation, such as cutting, grafting, layering, or plant tissue culture. These methods are highly effective for this goal because they rely on asexual reproduction, utilizing existing vegetative

parts like stems or apical meristems from a single parent to grow new plants, which guarantees that all offspring are exact genetic clones possessing the desired traits. Additionally, these techniques bypass the lengthy natural processes of flowering, pollination, and seed germination, allowing the farmer to rapidly cultivate a massive scale of high-yield or disease-resistant crops in a short amount of time.

10. Suresh prepares slides with pollen grains in different sugar concentrations (0%, 2.5%, 5%, 7.5%, 10%) to study the germination of pollen.
- What are the different hypotheses which can be tested using this set-up?
 - What parameters should be kept the same in this set-up?

Ans :

- One hypothesis Suresh could test is that there is a specific, optimum sugar concentration (e.g., 5% or 7.5%) that yields the highest rate of pollen germination and the longest pollen tube growth. Another hypothesis could be that extreme conditions, such as the complete absence of sugar (0%) or a very high concentration (10%), will inhibit or significantly slow down pollen germination compared to moderate sugar levels.
 - To ensure the experiment is a fair test, Suresh must strictly control several parameters, including using pollen grains from the exact same plant species, maintaining the same environmental temperature and humidity for all slides, using equal volumes of the sugar solution drops, and allowing the exact same time duration for the pollen to germinate before observing them under the microscope.
11. Look at the picture given below and think in line with the given prompts and find out which type(s) of pollination might have been followed in these flowers -

Tomato	Wheat	Papaya
		
Stamens cover the stigma.	Flowers open after pollination.	Male and female flowers are often borne on different papaya trees.

without medical advice. Emotional well-being and family support are vital for her health. ASHA workers are trained community health workers in India who offer advice on maternal care and safe deliveries.

7.2 What does it mean to be sexually mature?

Sexual maturation means the body becomes capable of reproduction, such as producing sperm in boys and menstrual cycles in girls. Sexual maturity happens gradually during adolescence alongside overall body growth. Being sexually mature does not mean a person is emotionally or mentally ready for adult responsibilities. Emotional maturity involves handling feelings, communicating clearly, and making thoughtful decisions, which takes longer to develop.

8. HOW CAN UNWANTED PREGNANCIES AND INFECTIONS BE PREVENTED?

Sexual activity involves close physical contact which can transmit Sexually Transmitted Infections or STIs. Common STIs include gonorrhoea, herpes, syphilis, genital warts, and HIV which can lead to AIDS. Using condoms acts as a barrier to prevent the transmission of STIs and also helps prevent pregnancy. Contraceptive methods are used to prevent unwanted pregnancies. Barrier methods like condoms or vaginal covers stop sperm from reaching the egg. Oral pills change hormone levels to stop the release of eggs but may have side effects. Intra-Uterine Devices like Copper-T are placed inside the uterus to avoid pregnancy but can sometimes cause irritation. Surgical methods block the vas deferens in males or the fallopian tubes in females to ensure sperm and egg cannot meet. Abortion is a medical or surgical procedure to stop an unwanted pregnancy and is usually done within the first trimester. Pre-natal sex determination is strictly prohibited by law in India to prevent selective abortion based on gender and to maintain a healthy sex ratio. Indian scientists at the Central Drug Research Institute developed a safe non-steroidal and non-hormonal oral contraceptive pill taken once weekly.

PAUSE AND PONDER

1. In a china-rose (hibiscus or gudhal) plant, a pollen tube grows and continues through the style after pollen lands on the stigma. Which process is about to happen next?

Ans :

The process of fertilisation is about to happen next. The male gamete will travel down the pollen tube to reach the ovule and eventually fuse with the female egg cell.

Look at the pictures of calotropis (madar) seeds and dandelion seeds given below. Can you guess what kind of seed dispersal these seeds are adapted for?



(a) Milkweed seeds



(b) Dandelion seeds

Ans :

These seeds are adapted for dispersal by wind. Their feathery, lightweight structures allow them to float easily and be carried over long distances by air currents.

3. A farmer plants two varieties of maize side by side, but notices that seeds form only when pollen from one variety reaches the stigma of the other. What type of pollination is this?

Ans :

This is an example of cross-pollination. The pollen is being transferred from the anther of a flower on one maize plant to the stigma of a flower on a completely different maize plant.

a much poorer performance with a fruit set of approximately 26% and a devastatingly high fruit drop of 35%. This data clearly shows that Orchard B retained and developed far more healthy fruits than Orchard A.

- (iv) I infer that the active presence of bee colonies is a highly effective intervention for apple farming. Efficient cross-pollination facilitated by the bees directly leads to healthier fruit development (higher fruit set) and stronger fruit retention (lower fruit drop), ultimately guaranteeing a much higher and more stable crop yield for the farmers despite the broader environmental decline in natural pollinators.

13. A student claims, “In humans, ovulation always happens on day 14 of the menstrual cycle”. Critically examine this claim and state whether the claim is correct or not. Give at least two reasons for your answer.

Ans :

The student's claim is incorrect because it uses the absolute word “always”. While day 14 is often taught as the average day of ovulation in a textbook 28-day cycle, it is not a universal rule for every female. Firstly, the total length of a normal menstrual cycle varies significantly from person to person, typically ranging between 21 to 35 days, which means the actual day of ovulation shifts accordingly depending on the individual's unique cycle length. Secondly, a woman's cycle and the timing of ovulation can fluctuate from month to month due to various external and internal factors, such as high stress levels, changes in diet, illness, or natural hormonal imbalances.

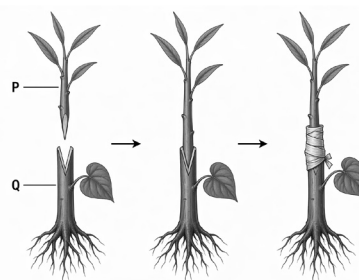
OBJECTIVE QUESTIONS

- Which of the following statements best describes the biological process of reproduction?
 - It is the process by which living beings produce identical copies of themselves without variations.
 - It is a biological process by which living beings produce new individuals of their own kind.
 - It is a process that occurs only in multicellular organisms to ensure the survival of the individual.
 - It is a mechanism by which organisms increase their lifespan continuously.

Ans : (B)

Reproduction is a fundamental biological process through which living organisms produce new individuals of their own kind. It ensures the continuity of life on Earth, allowing species to persist over generations. While it does not increase an individual's lifespan, it guarantees that life continues even after the parent organisms age and eventually die.

- A horticulturist performs the plant propagation procedure shown in the diagram. When this newly formed plant matures and bears fruit, which plant's genetic characteristics will the fruit primarily express, and why?



- Plant Q, because the root system provides all nutrients required for fruit development.
- Plant P, because the upper scion portion dictates the formation of flowers and fruits.
- A blend of P and Q, because their vascular tissues have permanently fused together.
- Neither, because this specific method only produces sterile vegetative leaf growth.

Ans : (B)

In grafting, the upper stem (scion, Label P) determines the genetic characteristics of the shoot system, including leaves, flowers, and fruits. The lower stem (stock, Label Q) merely provides the root system for water and nutrient absorption. Therefore, the fruits will express Plant P's traits, not Q's or a blend.

- In vegetative propagation, plants like Bryophyllum can sprout new plants without producing seeds. Which part of the Bryophyllum plant is responsible for sprouting tiny plantlets?
 - Fleshy underground stem
 - Root nodules
 - Leaves
 - Apical meristem

Ans : (C)

- (B) Wind is a highly directed and efficient agent that guarantees every pollen grain reaches a stigma.
- (C) Wind pollination is a random process with a lower probability of success, requiring massive pollen production to ensure fertilization.
- (D) Insect-pollinated plants naturally lack the biological capacity to produce large quantities of pollen.

Ans : (C)

Wind pollination relies entirely on random air currents, making it highly inefficient since most pollen is lost and never reaches a compatible stigma. To counter this low probability of success, wind-pollinated plants must produce enormous quantities of lightweight pollen, maximizing the slim chances that a few grains will successfully land and fertilize.

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31. Botanists catalogued the structural adaptations of three different flowering plants to understand their primary methods of transferring genetic material. Based on the structural traits, identify the most likely agents of pollination for Plant P and Plant Q respectively.

Plant Type	Pollen Characteristics	Stigma Characteristics	Nectar Production
Plant P	Light and dry	Long and feathery	Absent
Plant Q	Sticky and spiny	Flat and sticky	Present
Plant R	Large and heavy	Short and concealed	Present

- (A) Plant P: Wind, Plant Q: Insects
- (B) Plant P: Water, Plant Q: Wind
- (C) Plant P: Insects, Plant Q: Wind
- (D) Plant P: Insects, Plant Q: Water

Ans : (A)

Specific structural adaptations dictate the mode of pollination. Light, dry pollen and feathery stigmas are classic features for wind pollination, allowing grains to be caught by air currents. In contrast, sticky pollen, sticky stigmas, and nectar production are specialized traits designed to attract insects, ensuring pollen successfully attaches to their bodies.

32. Variation among individuals is considered crucial for the survival of a species over long periods. How does sexual reproduction primarily contribute to this survival advantage?
- (A) By ensuring that every offspring is identical, preserving the best traits perfectly.
- (B) By helping some individuals adapt better to changing environmental conditions.
- (C) By increasing the total number of chromosomes in every successive generation.
- (D) By eliminating all genetic defects through spontaneous mutations.

Ans : (B)

Sexual reproduction continuously generates unique genetic combinations through meiosis and gamete fusion. This inherent variation means that within a population, certain individuals may possess traits better suited to survive unexpected environmental shifts, new diseases, or harsh conditions. Thus, variation acts as a vital buffer, helping the species adapt and avoid complete extinction.

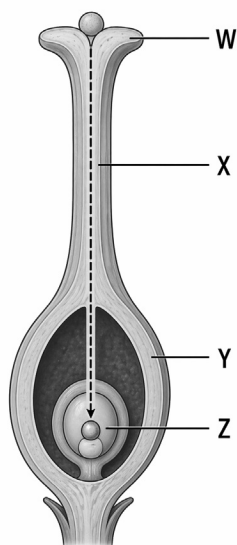
33. Many aquatic animals like frogs and fish exhibit external fertilisation. What is the primary cause for these animals producing vastly larger numbers of eggs compared to animals with internal fertilisation?
- (A) They have unlimited internal space to store thousands of developing embryos.
- (B) External fertilisation offers extreme protection, so they maximize offspring production.
- (C) A large number of eggs are destroyed by water currents or eaten by predators.
- (D) Their eggs contain no yolk and require immediate external nutrition to survive.

Ans : (C)

In external fertilization, eggs and sperm are released openly into the water. This environment is highly hazardous, as countless eggs are routinely washed away by strong currents or consumed by various aquatic predators. To ensure that at least a few offspring survive to maturity, these animals must produce enormous quantities of eggs.

34. According to the variations in reproductive strategies among animals, identify the incorrect statement regarding the correlation between the mode of fertilisation and offspring survival.
- (A) Fish rely on external fertilisation and have a very low estimated survival rate of young ones.

8. Based on the provided diagram, which label correctly identifies the specific structure where the zygote will initially form following the event indicated by the dashed line?



- (A) Structure W
(B) Structure X
(C) Structure Y
(D) Structure Z

Ans : (D)

The diagram illustrates a pistil with pollen tube growth. The dashed line indicates the pollen tube delivering male gametes down the style to the ovule (Label Z) located inside the ovary (Label Y). Fertilisation, which is the fusion of gametes, occurs specifically inside the ovule, where the zygote initially forms.

9. During the observation of yeast under a microscope after incubating it in a warm sugar solution, what indicates that the yeast is actively reproducing?
- (A) The formation of a protective cyst around a single parent cell.
(B) The fusion of two separate yeast cells to form a zygote.
(C) The emergence of small, round outgrowths or buds from the parent cells.
(D) The breakdown of a single yeast cell into multiple identical fragments simultaneously.

Ans : (C)

Yeast reproduces asexually through a process known as budding. When placed in a warm and favorable sugar solution, yeast cells become active and begin to duplicate. This is visible under a microscope as small, round outgrowths,

called buds, emerging from the parent cells, which eventually enlarge and separate to live independently.

10. Fungi like *Rhizopus* grow rapidly on moist bread. Identify the specific structures responsible for this widespread and rapid reproduction.
- (A) Gametes formed in the hyphae
(B) Tiny round spores formed inside a sac-like structure
(C) Small buds that detach from the fungal stem
(D) Vegetative branches that layer into the bread surface

Ans : (B)

Fungi such as *Rhizopus* reproduce asexually through spore formation. They possess thread-like structures ending in round sacs. Inside these sacs, millions of tiny, lightweight spores are produced. When released, these single-celled spores float easily through the air and germinate quickly upon settling on a moist, nutrient-rich surface like fresh bread.

11. In all the asexually reproducing organisms discussed, the central process behind this type of reproduction is mitosis. What is the immediate consequence of this mechanism for the offspring?
- (A) They possess half the number of chromosomes as the parent.
(B) They are genetically identical to the parent and are called clones.
(C) They exhibit high genetic variation essential for evolution.
(D) They require two parents to contribute genetic material equally.

Ans : (B)

Asexual reproduction relies entirely on mitosis, a type of cell division that produces daughter cells with the exact same number of chromosomes as the parent cell. Consequently, the offspring generated through these methods are genetically identical to the single parent organism. These genetically uniform individuals are scientifically referred to as clones.

12. **Assertion (A):** Refrigeration of perishable food prevents their spoilage from moulds and bacteria.
Reason (R): Lower temperatures slow down or completely stop the reproduction and growth of spores present in the air.
(A) Both A and R are true and R is the correct explanation of A

In certain plants like Bryophyllum, vegetative propagation occurs through the leaves. The margins of the leaves sprout tiny plantlets, which can eventually drop off and grow into independent, new plants. This is a natural method of asexual reproduction where only one parent is involved, producing genetically identical offspring without the need for seeds.

4. A student observed the growth of Rhizopus (bread mould) under different environmental conditions over a period of 5 days. Based on the documented observations, which combination of environmental factors is most favorable for the rapid germination of fungal spores?

Setup	Bread Condition	Temperature (°C)	Relative Spore Growth (Day 5)
Setup 1	Dry	30	None
Setup 2	Moist	5	Very low
Setup 3	Moist	30	Very high
Setup 4	Dry	5	None

- (A) Spore formation requires low temperature and dry conditions to prevent spoilage.
 (B) Spores germinate most effectively in the presence of both moisture and warm temperatures.
 (C) Temperature has no effect on mould growth as long as the bread remains moist.
 (D) Moisture is the sole limiting factor for asexual reproduction in simple fungi.

Ans : (B)

Maximum spore germination occurs exclusively when both moisture and warm temperatures (30°C) are provided simultaneously. When either adequate moisture or warmth is absent, fungal growth is severely stunted or completely non-existent. This confirms that these two specific environmental factors are absolutely essential for the rapid asexual reproduction of bread mould.

5. While observing the technique of cutting in a field, at what approximate angle should the stem cuttings be inserted into the soil mixed with compost?
 (A) 15–30 degrees
 (B) 45–60 degrees
 (C) 75–90 degrees
 (D) 90–120 degrees

Ans : (B)

According to the agricultural practices described for cutting, the prepared stem cuttings should be inserted into the soil mixed with compost at an angle of about 45 to 60 degrees from the soil surface. This specific orientation helps the cutting establish roots properly and facilitates optimal exposure to required nutrients and moisture from the soil.

6. In the process of grafting, two plants are involved to create a new plant structure. Which of the following accurately describes the components used?
 (A) Both plants must be wild varieties with strong root systems.
 (B) A healthy stem piece (graft) is inserted into a slit created on a rooted plant.
 (C) Two stem pieces are tied together and planted directly into the soil.
 (D) The rooted plant provides the apical meristem for tissue culture propagation.

Ans : (B)

Grafting involves taking a healthy rooted plant and creating a wound or slit on its twig. A healthy stem piece from another desirable plant variety is then inserted and fitted into this slit. The joint is protected and allowed to heal, resulting in the successful combination and growth of the two distinct plant parts together.

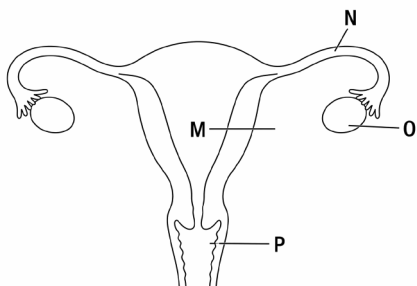
7. Which of the following is the primary advantage of propagating plants using the tissue culture technique?
 (A) It requires minimal scientific equipment and can be done openly in fields.
 (B) It uses the apical meristem to produce healthy, virus-free plantlets ensuring high yields.
 (C) It naturally introduces wide genetic variations in crop plants like bananas.
 (D) It allows the direct fusion of male and female gametes in a laboratory setting.

Ans : (B)

Tissue culture has revolutionized farming practices, particularly for crops like bananas. By using the shoot tip, or apical meristem, farmers can be provided with healthy, mass-produced plantlets. This specific technique is highly effective as it helps eliminate virus-infected plants, thereby ensuring robust growth and significantly higher yields in agricultural production.

environmental stress occurs, the entire uniform population may be wiped out.

17. Identify the correct specific sites for the production of female gametes and the implantation of a developing embryo, respectively.



- (A) Gamete production at N; Implantation at M
 (B) Gamete production at O; Implantation at M
 (C) Gamete production at O; Implantation at N
 (D) Gamete production at M; Implantation at P

Ans : (B)

The ovary (Label O) is responsible for gametogenesis in females, producing mature eggs (gametes). After fertilisation in the fallopian tube (Label N), the zygote undergoes divisions and travels to the uterus (Label M). Here, it implants into the thickened inner lining of the uterus to develop into a foetus.

18. In sexual reproduction, a biological problem arises if both parents contribute their full set of chromosomes to the offspring. How is this problem solved in nature?
- (A) By replacing mitosis with a special cell division called vegetative propagation.
 (B) By a special type of cell division called meiosis that halves the chromosome number.
 (C) By doubling the chromosome number in every generation to maintain stability.
 (D) By destroying half the chromosomes immediately after fertilization occurs.

Ans : (B)

If offspring received full chromosome sets from both parents, the chromosome number would continuously double every generation. Nature solves this through meiosis, a specialized cell division that reduces the diploid chromosome number to half, creating haploid gametes. When these gametes fuse, the original diploid number is correctly restored in the zygote.

19. Humans have 46 chromosomes in their regular body cells. Following meiosis, how many chromosomes does every normal human gamete (sperm or egg) contain?
- (A) 46
 (B) 92
 (C) 23
 (D) 12

Ans : (C)

Human body cells contain 46 chromosomes arranged in 23 pairs. During the process of meiosis, these pairs separate so that each resulting gamete receives exactly one chromosome from every pair. Therefore, a normal human gamete, whether a sperm or an egg, carries exactly 23 chromosomes, ensuring proper genetic transmission upon fertilization.

20. In flower buds, the coloured projections are usually covered by a thin, flat, green covering. What is this outermost whorl of the flower called?
- (A) Petal
 (B) Stigma
 (C) Sepal
 (D) Anther

Ans : (C)

Before a flower blooms, its delicate internal parts are enclosed in a bud. The outermost whorl of this bud consists of a thin, flat, leaf-like green covering designed to protect the developing structure. This protective green layer is called a sepal, which safely guards the colorful petals and reproductive organs inside.

21. Consider the following characteristics related to pollination strategies in plants.
1. Pollen grains are light, small, and produced in huge numbers.
 2. Flowers are brightly coloured and produce sweet nectar.
 3. The stigma is long and feathery to trap pollen.
 4. Pollen grains are large, sticky, or spiny.
- Which combination of statements correctly represents the features of insect-pollinated plants?
- (A) 1 and 3
 (B) 2 and 4
 (C) 1, 2, and 4
 (D) 2, 3, and 4

Ans : (B)

Insect-pollinated plants must attract specific pollinators. To achieve this, their flowers are

- (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The assertion is true as refrigerating food greatly extends its shelf life by preventing microbial spoilage. The reason is also true and directly explains the assertion. Spores require warmth and moisture to germinate. Lowering the temperature through refrigeration removes the necessary warmth, effectively slowing or halting the reproduction of moulds and bacteria.

- 13.** A field researcher documented the presence of reproductive organs in the flowers of four different plant species. Which of the following conclusions can be correctly drawn regarding the reproductive capabilities of these specific species?

Plant Species	Presence of Stamen	Presence of Pistil
Species W	Present	Absent
Species X	Present	Present
Species Y	Absent	Present
Species Z	Present	Present

- (A) Only Species W and Y possess the necessary structures to undergo self-pollination.
 (B) Species X and Z are structurally capable of successfully performing self-pollination.
 (C) Species W represents a female flower and must strictly undergo cross-pollination.
 (D) Species Y produces distinct pollen grains but cannot ultimately form a mature fruit.

Ans : (B)

Self-pollination requires the direct transfer of pollen from an anther to the stigma within the same flower. Only species possessing both male (stamen) and female (pistil) reproductive parts can achieve this. Species lacking either part are unisexual and fundamentally incapable of self-pollination, relying entirely on cross-pollination to reproduce successfully.

- 14.** Arrange the following steps of the layering method in the correct chronological sequence.
1. Water the buried twig regularly and observe the growth of new leaves.
 2. Select a flexible, thin twig of a tree or a shrub.
 3. Cut the rooted twig from the parent plant to grow as a new plant.

4. Bury the middle part of the twig under the soil surface.
 5. Wait for roots to develop from the buried area of the twig.
- (A) 2, 4, 1, 5, 3
 (B) 4, 2, 5, 1, 3
 (C) 2, 1, 4, 3, 5
 (D) 2, 4, 5, 1, 3

Ans : (A)

In layering, one first selects a flexible twig (2). Next, the middle part is buried under the soil (4). The area is watered regularly to encourage growth (1). After some days, roots develop from the buried section (5). Finally, the newly rooted twig is detached from the parent plant (3).

- 15.** Who among the following scientists proved that new life always comes from preexisting life, strengthening the germ theory of disease?
 (A) P. Maheshwari
 (B) Louis Pasteur
 (C) Subhash Mukhopadhyay
 (D) Gregor Mendel

Ans : (B)

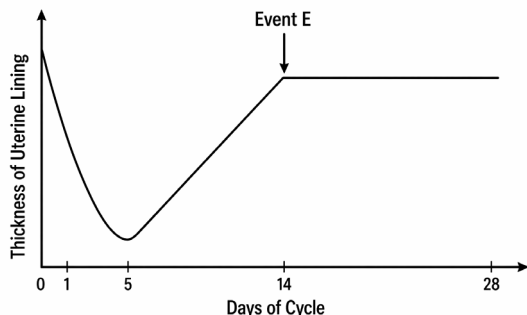
Louis Pasteur conducted pivotal experiments proving that new life arises only from pre-existing life, effectively disproving the long-held belief in spontaneous generation. His ground breaking work significantly strengthened the germ theory of disease and eventually led to modern, essential practices like food preservation and the rigorous sterilization of medical instruments.

- 16.** Why might an organism reproducing exclusively through asexual reproduction be at a disadvantage in a rapidly changing environment?
 (A) Asexual reproduction produces offspring much slower than sexual reproduction.
 (B) The offspring lack genetic variation, making adaptation to new conditions difficult.
 (C) Asexual reproduction requires excessive energy to find a suitable mate.
 (D) The offspring always have half the chromosome number, leading to weakness.

Ans : (B)

Asexual reproduction produces clones, meaning offspring are genetically identical to the parent. While this allows for rapid population growth in stable conditions, it becomes a disadvantage in changing environments. The lack of genetic variation means that if a new disease or

26. What biological process is represented by “Event E” at Day 14, which directly triggers the subsequent maintenance of the uterine lining thickness?



- (A) Shedding of the unfertilized egg and blood vessels
 (B) Release of a mature egg from the ovary
 (C) Implantation of the fertilised zygote into the uterine wall
 (D) Rapid cellular division of the zygote to form an embryo

Ans : (B)

Event E at day 14 represents ovulation, the release of a mature egg from the ovary. Following ovulation, the uterine lining reaches maximum thickness and is enriched with blood vessels to prepare for potential embryo implantation. If implantation (Option C) does not occur, the lining eventually sheds (Option A).

27. **Assertion (A):** Sexual reproduction in plants creates genetic variation among the offspring.

Reason (R): The fusion of a male gamete with a female gamete brings together unique combinations of chromosomes from two different parents.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The assertion is true because sexual reproduction indeed leads to genetic variation. The reason correctly explains this phenomenon: the process involves the fusion of haploid male and female gametes during fertilisation. This merging combines unique chromosomal combinations

derived through meiosis from two distinct parents, resulting in genetically diverse and adaptable offspring.

28. Choose the correct sequential order of steps involved in the process of artificial hybridisation in agricultural crop production.

1. Manual transfer of desired pollen to the stigma
2. Removal of stamens from the flowers
3. Selection of plants with desirable characters
4. Covering the flower with a bag to prevent self-pollination

- (A) 3, 2, 4, 1
 (B) 2, 4, 1, 3
 (C) 3, 4, 2, 1
 (D) 1, 3, 2, 4

Ans : (A)

Artificial hybridisation begins with the careful selection of parent plants possessing desirable traits (3). Next, stamens are removed from the selected female parent's flowers to avoid unwanted self-pollination (2). The emasculated flower is then securely covered with a bag (4). Finally, desired pollen is manually transferred onto the receptive stigma (1).

29. Which Indian scientist is highly recognized as the ‘Father of Indian Embryology’ and developed the technique of in-vitro fertilisation in flowering plants?

- (A) Subhash Mukhopadhyay
 (B) Louis Pasteur
 (C) P. Maheshwari
 (D) Gregor Mendel

Ans : (C)

P. Maheshwari is widely celebrated as the ‘Father of Indian Embryology’. He was a pioneering scientist who successfully developed the complex technique of in-vitro fertilisation in flowering plants. By artificially fusing an egg and a male gamete in a test tube, he laid the foundation for creating new, valuable hybrid plant varieties.

30. Based on the data comparing wind-pollinated and insect-pollinated plants, why do wind-pollinated grasses produce significantly more pollen grains per flower (5,00,000–10,00,000) compared to insect-pollinated plants (20,000–40,000)?

- (A) Wind-pollinated plants require more pollen to feed the insects that visit them.

typically brightly coloured and produce nectar (Statement 2). Furthermore, their pollen grains are large, sticky, or spiny so that they can easily adhere to the bodies of visiting insects (Statement 4). Statements 1 and 3 describe wind-pollinated plants.

22. Match the parts of a flower in List-I with their correct description in List-II.

List-I (Flower Part)			List-II (Description)
P.	Stamen	1.	Female part comprising stigma, style, and ovary
Q.	Pistil	2.	Swollen base containing ovules
R.	Anther	3.	Male part consisting of filament and anther
S.	Ovary	4.	Produces pollen grains containing male gametes

- (A) P-3, Q-1, R-4, S-2
 (B) P-1, Q-3, R-2, S-4
 (C) P-4, Q-2, R-3, S-1
 (D) P-3, Q-4, R-1, S-2

Ans : (A)

The stamen (P) is the male reproductive part (3). The pistil (Q) is the female reproductive part consisting of three components (1). The anther (R), located at the tip of the stamen, specifically produces the pollen grains (4). The ovary (S) is the swollen base of the pistil containing the ovules (2).

23. In an experimental setup to study pollination in pea plants, stamens are carefully removed from a juvenile flower bud, and the bud is wrapped in a muslin cloth bag. What is the primary purpose of this procedure?
- (A) To prevent the flower from undergoing any form of photosynthesis.
 (B) To ensure that natural self-pollination occurs undisturbed.
 (C) To prevent self-pollination and control the source of pollen reaching the stigma.
 (D) To protect the stamens from being eaten by pollinating insects.

Ans : (C)

Removing stamens from a juvenile flower bud ensures that the flower cannot self-pollinate. Wrapping the emasculated flower bud in a muslin

cloth bag prevents unwanted pollen from wind or insects from reaching the stigma. This controlled technique allows researchers or breeders to manually introduce specific, desired pollen for artificial hybridisation experiments.

24. Which of the following statements correctly differentiates between self-pollination and cross-pollination?
- (A) Self-pollination requires external agents, while cross-pollination happens spontaneously.
 (B) Self-pollination occurs within the same flower or plant, whereas cross-pollination involves a different plant of the same type.
 (C) Self-pollination produces fruits, while cross-pollination only produces vegetative growth.
 (D) Self-pollination involves the transfer of eggs, whereas cross-pollination involves the transfer of pollen.

Ans : (B)

Pollination is the transfer of pollen grains from anther to stigma. If this transfer happens within the same flower or between flowers on the same individual plant, it is termed self-pollination. In contrast, cross-pollination occurs when pollen is successfully transferred from the anther of one plant to the stigma of another plant.

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25. Following successful fertilisation in a flowering plant, specific floral parts transform to support seed dispersal and growth. Identify the correct pair representing this post-fertilisation transformation.
- (A) Ovary develops into a seed; Ovule develops into a fruit
 (B) Ovary develops into a fruit; Ovule develops into a seed
 (C) Stigma develops into a fruit; Style develops into a seed
 (D) Anther develops into a fruit; Pollen tube develops into a seed

Ans : (B)

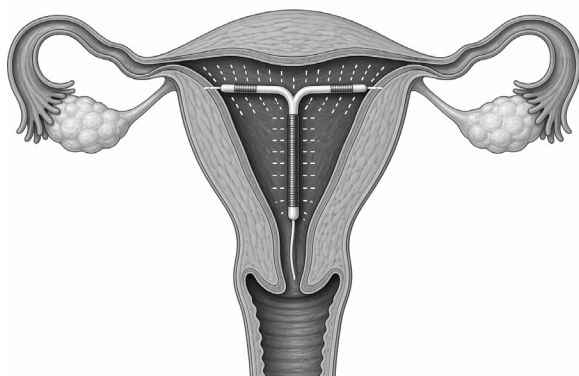
After fertilisation occurs, the flower undergoes significant changes. The ovules, which contain the fertilised egg (zygote), gradually develop and mature into seeds. Concurrently, the thick ovary surrounding these ovules enlarges and transforms into a fruit. This fruit ultimately protects the enclosed seeds and greatly assists in their eventual dispersal across different environments.

- (B) Birds use internal fertilisation and exhibit a moderate to high survival rate of their young.
- (C) Frogs utilize internal fertilisation and produce 5,000 to 50,000 eggs at a time.
- (D) Lizards have internal fertilisation, produce fewer eggs, and show moderate offspring survival.

Ans : (C)

The statement regarding frogs is factually incorrect based on the reproductive data. Frogs are amphibians that rely on external fertilisation, releasing thousands of eggs directly into the water where they meet sperm. Because of this external, unprotected method, the resulting young ones face extremely high mortality rates and low overall survival chances.

- 35.** What is the primary function of the specific device depicted inside the uterine cavity?



- (A) It acts as a mechanical barrier covering the cervix to prevent sperm entry into the vagina.
- (B) It systematically alters hormonal balances to completely stop the ovaries from releasing mature eggs.
- (C) It prevents unwanted pregnancy by acting as an Intra-Uterine Device that interferes with sperm and implantation.
- (D) It provides a permanent surgical block by physically cutting and tying off the fallopian tubes.

Ans : (C)

The diagram illustrates a Copper-T, an Intra-Uterine Device (IUD) placed inside the uterus. It prevents pregnancy by altering the uterine environment, often through released ions, which impedes sperm movement and prevents embryo implantation. It is not a barrier method (Option A), an oral hormone pill (Option B), or surgery (Option D).

- 36.** Arrange the intermediate developmental stages of a butterfly's life cycle in the correct chronological sequence, starting from the egg.

1. Pupa
2. Adult butterfly
3. Egg
4. Larva

- (A) 3, 1, 4, 2
- (B) 3, 4, 1, 2
- (C) 4, 3, 1, 2
- (D) 3, 2, 4, 1

Ans : (B)

The life cycle of a butterfly begins with an egg (3). The egg hatches into a feeding stage called a larva or caterpillar (4). Once enough nutrition is accumulated, it transforms into a resting, transitional stage known as a pupa (1). Finally, it emerges from the pupa as a fully formed adult butterfly (2).

- 37.** Consider the following statements regarding the nourishment of developing embryos in animals.

1. In birds, the egg contains enough yolk to nourish the embryo until it hatches.
2. In mammals, the zygote grows and develops inside the female body, drawing nourishment directly.
3. In fish and amphibians, the mother's body provides a continuous supply of yolk throughout development.

Which of the given statements is/are correct?

- (A) 1 and 2 only
- (B) 2 and 3 only
- (C) 1 and 3 only
- (D) 1, 2, and 3

Ans : (A)

Statements 1 and 2 accurately describe embryo nourishment in birds and mammals, respectively. Statement 3 is incorrect because fish and amphibians produce thousands of eggs simultaneously. A mother's body cannot physically supply large quantities of yolk for so many embryos; instead, the minimal yolk only sustains the embryo until it hatches into a larva.

- 38.** A scientist observes the eggs of an unknown animal species. The eggs are laid in hundreds but contain only a very small amount of yolk. Based on the reproductive strategies studied, what is the most likely developmental pathway for this species?

- (A) The egg will directly hatch into a fully mature, miniature adult.
- (B) The egg will hatch into an intermediate feeding stage (larva) to gain further nutrition.
- (C) The embryo will remain dormant in the egg for several years until external nutrients arrive.
- (D) The egg will require immediate internal fertilisation by a male after being laid.

Ans : (B)

When eggs are produced in massive numbers with minimal yolk, the stored nutrition is insufficient for complete development. Therefore, the egg hatches early into a larva. This intermediate stage is essentially a feeding phase, where the organism consumes organic waste to accumulate enough energy before transforming into its final adult form.

39. Biological data was collected regarding the reproductive strategies of four distinct animal species. Analyzing these evolutionary strategies, which species is most likely to have the highest survival rate for its young ones, and for what biological reason?

Animal Species	Mode of Fertilisation	Average Number of Eggs per Cycle	Embryo Protection Level
Species K	External	10,000	None (released directly in water)
Species L	Internal	5	Hard protective shell covering
Species M	Internal	1	Develops inside mother's body
Species N	External	500	Soft jelly-like covering

- (A) Species K, because producing a massive number of eggs guarantees maximum survival.
- (B) Species L, because hard external shells completely eliminate all potential predation risks.

- (C) Species M, because internal development provides the highest level of physical protection.
- (D) Species N, because the jelly covering provides sufficient camouflage in aquatic environments.

Ans : (C)

Internal fertilisation combined with internal embryonic development provides the maximum physical protection and sustained nourishment against external environmental hazards and predators. While producing fewer eggs, this advanced reproductive strategy ensures the highest probability of survival for the offspring compared to methods involving external fertilisation or laying vulnerable eggs in water.

40. The male reproductive system in humans consists of several highly specialized organs. Which specific structure is responsible for both the production of sperm and the secretion of hormones that regulate physical changes during puberty?
- (A) Vas deferens
 - (B) Prostate gland
 - (C) Testis
 - (D) Urethra

Ans : (C)

The testes are the primary reproductive organs in human males. Located in the scrotum, they perform dual critical functions: producing male germ cells known as sperm, and secreting hormones like testosterone. These hormones not only regulate ongoing sperm production but also trigger the significant physical transformations boys experience during the onset of puberty.

41. **Assertion (A):** In human males, the testes are located in a pouch called the scrotum outside the main abdominal cavity.
Reason (R): Sperm production requires a temperature slightly lower than the normal internal body temperature.
- (A) Both A and R are true and R is the correct explanation of A
 - (B) Both A and R are true but R is not the correct explanation of A
 - (C) A is true but R is false
 - (D) A is false but R is true

Ans : (A)

The assertion correctly states that testes are housed in the scrotum. The reason is also factually correct and perfectly explains the assertion. Optimal

spermatogenesis (sperm production) cannot occur at the standard core body temperature. The scrotum provides an environment that is slightly cooler, making it essential for the development of healthy, viable sperm.

42. A medical chart outlines the standard physiological phases of a typical 28-day human menstrual cycle. What would be the immediate physiological consequence if fertilisation does not successfully occur after the events of Day 14?

Phase (Days)	State of Uterine Lining	Major Biological Event
Days 1–5	Shedding and breaking down	Menstrual bleeding occurs
Days 6–13	Gradually rebuilding thickness	Immature egg starts maturing
Day 14	Highly vascularized	Ovary releases a mature egg
Days 15–28	Thickest and rich in blood vessels	Waiting for a fertilised egg

- (A) The uterine lining will continue to thicken indefinitely to support a future zygote.
 (B) The mature unfertilised egg will implant itself into the uterine lining and remain dormant.
 (C) The thickened uterine lining will break down, leading directly to the events of Days 1–5.
 (D) The ovary will immediately release another mature egg on Day 15 to ensure pregnancy.

Ans : (C)

The uterine lining reaches its maximum thickness between days 15 and 28 to prepare for the implantation of a fertilised egg. If fertilisation fails to occur, this nutrient-rich vascular preparation is no longer required. Consequently, the thickened lining breaks down and sheds, initiating the menstruation phase observed during days 1 to 5.

43. As sperm travel from the testes through the vas deferens, glands secrete fluids to assist them. Which two glands are primarily responsible for adding fluid that nourishes the sperm and helps them remain active and motile?
 (A) Seminal vesicles and prostate gland
 (B) Ovary and cervix
 (C) Urethra and scrotum
 (D) Pituitary and thyroid glands

Ans : (A)

During their journey through the male reproductive tract, sperm receive crucial secretions from specific accessory glands, namely the seminal vesicles and the prostate gland. These glandular fluids provide essential nutrients and a supportive liquid medium, which together nourish the sperm and significantly enhance their motility, ensuring they can actively swim toward the egg.

44. In the human female reproductive system, the ovaries produce female germ cells (eggs). Through which specific anatomical structure does the mature egg travel to reach the uterus?

- (A) Cervix
 (B) Vagina
 (C) Oviduct (Fallopian tube)
 (D) Urethra

Ans : (C)

In human females, once an ovary releases a mature egg during ovulation, it is caught and transported by the oviduct, also commonly known as the fallopian tube. This vital tube acts as a specialized passageway connecting the ovary to the uterus, and it is typically the precise location where fertilisation by a sperm occurs.

45. Consider the following structural and functional differences between human male and female gametes based on the provided table.

1. Sperm is very small in size, whereas the egg is large.
2. Sperm is produced in millions, while eggs are produced in very few numbers.
3. Stored nutrients are abundant in sperm but absent in the egg.
4. Sperm is actively motile, whereas the egg is non-motile.

Which of the statements given above are correct?

- (A) 1, 2, and 4
 (B) 2, 3, and 4
 (C) 1, 3, and 4
 (D) 1, 2, and 3

Ans : (A)

Statements 1, 2, and 4 correctly describe the distinct differences between sperm and eggs. Sperm are small, motile, and produced in vast numbers. Statement 3 is entirely incorrect because the reality is exactly the opposite: the large female egg contains stored nutrients to support early embryonic development, whereas the tiny sperm lacks such reserves.

While sexual maturity refers strictly to the physiological capability of reproduction (like sperm production or menstruation), emotional maturity is entirely psychological. Developing emotional maturity takes significantly longer and involves learning how to manage complex feelings, communicating effectively with others, and consistently making responsible, well-thought-out life choices during and beyond adolescence.

55. Sexually Transmitted Infections (STIs) are a serious health concern associated with unprotected sexual activity. Which of the following diseases is considered the 'odd one out' because it is currently not curable?
- (A) Gonorrhoea
(B) Syphilis
(C) HIV
(D) Mild bacterial infections

Ans : (C)

STIs are transmitted through intimate physical contact. While bacterial infections such as gonorrhoea and syphilis can generally be treated and cured with antibiotics, viral infections present greater challenges. Specifically, HIV (Human Immunodeficiency Virus), which can eventually lead to AIDS, is a severe, life-long condition that currently has no permanent medical cure available.

56. Consider the following statements regarding various contraceptive methods used to prevent unwanted pregnancies.
1. Condoms act as physical barriers that stop sperm from reaching the egg.
 2. Oral pills alter hormonal balances to prevent the release of eggs from the ovaries.
 3. Intra-Uterine Devices (IUDs) like Copper-T are completely free of any side effects.
 4. Surgical methods block the vas deferens in males or fallopian tubes in females.
- Which of the statements given above are correct?
- (A) 1, 2, and 4
(B) 2, 3, and 4
(C) 1, 3, and 4
(D) 1, 2, and 3

Ans : (A)

Statements 1, 2, and 4 accurately describe barrier, hormonal, and surgical contraceptive methods. Statement 3 is incorrect. While Intra-Uterine Devices (IUDs) like the Copper-T are highly effective at preventing pregnancy, they are not

completely without issues; they can sometimes cause irritation in the uterus, leading to discomfort or unexpected bleeding in some users.

57. Which of the following statements incorrectly describes the function or placement of the Intra-Uterine Device (IUD) known as Copper-T?
- (A) It is placed inside the female's uterus by a healthcare professional.
(B) It functions effectively as a barrier method to trap sperm in the vagina.
(C) It is used to avoid unwanted pregnancy over a long period.
(D) It may sometimes cause irritation to the inner lining of the uterus.

Ans : (B)

The statement is incorrect because a Copper-T is an Intra-Uterine Device, not a barrier method. Barrier methods, like condoms, physically block sperm in the vagina or cervix. In contrast, an IUD is inserted deep into the uterus, where it alters the internal environment, preventing sperm viability and inhibiting the implantation of an embryo.

58. **Assertion (A):** Prenatal sex determination is strictly prohibited by law in India.
Reason (R): The practice of self-selective abortion based on gender leads to a marked and dangerous imbalance in the societal sex ratio.
- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The assertion states a legal fact in India aimed at protecting unborn children. The reason provides the correct sociological and demographic explanation. Historically, prenatal sex determination has been maliciously misused for female foeticide (selective abortion). This discriminatory practice dangerously skews the natural male-to-female ratio, harming the structural balance of a forward-looking society.

59. Indian scientists at the Central Drug Research Institute (CDRI), Lucknow, developed a revolutionary contraceptive method provided through the National Family Planning Programme. What was this specific invention?
- (A) The world's first biodegradable sanitary pad

- (A) Both A and R are true and R is the correct explanation of A
- (B) Both A and R are true but R is not the correct explanation of A
- (C) A is true but R is false
- (D) A is false but R is true

Ans : (A)

The assertion correctly describes the process of menstruation. The reason provides the accurate physiological explanation. The body prepares the uterine lining every month specifically to receive and nourish a fertilised egg. If fertilisation fails to occur, this specialized preparation becomes redundant, leading to the shedding of the lining through the vagina.

- 51.** Consider the following statements regarding the stages of human pregnancy.

1. Pregnancy is divided into three stages called trimesters, lasting about nine months.
2. Major organs start forming in the developing embryo during the second trimester.
3. In the third trimester, the baby grows rapidly and prepares for life outside the womb.

Which of the statements given above is/are correct?

- (A) 1 and 2 only
- (B) 1 and 3 only
- (C) 2 and 3 only
- (D) 1, 2, and 3

Ans : (B)

Statements 1 and 3 are factually accurate descriptions of pregnancy stages. Statement 2 is incorrect because major organ formation begins much earlier. Specifically, the fundamental development of the embryo's major organs occurs during the first two months of the first trimester, not delayed until the second trimester as the statement suggests.

- 52.** In humans, biological sex is determined by sex chromosomes. Since females have XX chromosomes and males have XY, which parent ultimately determines the biological sex of a newly conceived baby?

- (A) The mother, because she provides the larger egg containing essential nutrients.
- (B) The mother, because she always contributes an X chromosome.
- (C) The father, because he contributes either an X or a Y chromosome.

- (D) Both parents equally determine the sex through a blend of hormones.

Ans : (C)

Human females possess XX chromosomes, meaning every egg always carries an X chromosome. Human males have XY chromosomes, producing sperm that carry either an X or a Y. Therefore, the father's sperm dictates the biological sex: if an X-bearing sperm fertilises the egg, a female (XX) develops; if a Y-bearing sperm fertilises, a male (XY) develops.

- 53.** Consider the following recommended hygiene practices during menstruation.

1. Use biodegradable sanitary pads or menstrual cups.
2. Clean the genital area with strong soaps to eliminate all natural bacteria.
3. Change menstrual pads regularly, typically every 4–6 hours.

Which of the given practices is/are medically advised for maintaining health?

- (A) 1 and 2 only
- (B) 2 and 3 only
- (C) 1 and 3 only
- (D) 1, 2, and 3

Ans : (C)

Statements 1 and 3 reflect excellent, recommended menstrual hygiene habits. Statement 2 is highly discouraged and incorrect. Washing the sensitive genital area with strong, harsh soaps can severely disrupt the natural, healthy bacterial balance, potentially leading to discomfort or infections. Only clean water is advised to maintain a safe and natural environment.

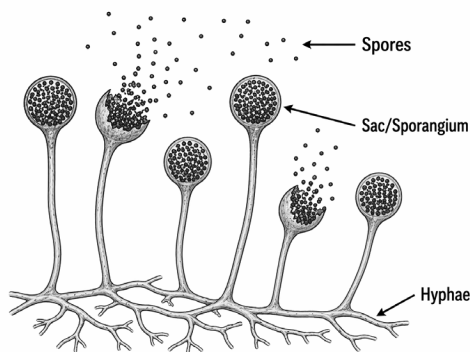
- 54.** As individuals grow through adolescence, they experience sexual maturation. However, what does it mean to be 'emotionally mature' as opposed to just sexually mature?

- (A) It means the body is fully physically capable of reproducing and bearing children.
- (B) It means handling feelings appropriately, communicating clearly, and making thoughtful decisions.
- (C) It means undergoing the physical production of sperm or the onset of menstrual cycles.
- (D) It means completely ignoring emotional responses to focus only on physical growth.

Ans : (B)

92. Draw a labelled diagram of fungi showing spore formation. How does this method help the organism survive?

Ans :



Spore formation is highly advantageous for fungi as spores are produced in massive numbers. These tiny, lightweight spores float easily through air currents, allowing the organism to spread over wide areas. Spores are well-protected and remain dormant in the environment until they encounter favorable conditions, such as adequate warmth and moisture. Once they settle on a suitable nutrient source like damp bread, they quickly germinate and grow into new fungal colonies, ensuring rapid population increase.

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93. A student claims that meiosis is essential for maintaining a constant chromosome number across generations in sexually reproducing organisms. Do you agree? Justify.

Ans :

Yes, I agree with this claim. Sexual reproduction involves the fusion of gametes from two parents. If gametes were formed by normal cell division (mitosis), the chromosome number would double with each passing generation. Meiosis is a special type of cell division that reduces the chromosome number to half (haploid) in gametes. When a male and a female gamete fuse during fertilization, the original (diploid) chromosome number is restored in the zygote, keeping the chromosome number constant across generations.

94. Compare self-pollination and cross-pollination based on the transfer of pollen and the requirement of external agents.

Ans :

Self-pollination is the transfer of pollen grains from the anther to the stigma of the same flower or another flower of the exact same plant. It generally does not strictly require external pollinating agents. In contrast, cross-pollination occurs when pollen is transferred from the anther of a flower on one plant to the stigma of a flower on a completely different plant of the same type. This process heavily relies on external agents like wind, water, insects, or birds to carry the pollen.

95. Trace the events that occur in a flower immediately after pollen reaches a compatible stigma until seed formation.

Ans :

Once a compatible pollen grain lands on the stigma, it germinates and produces a pollen tube that grows downwards through the style to reach the ovary. The male gamete travels through this tube and enters the ovule, where it fuses with the egg cell in a process called fertilization. This fusion creates a zygote, which subsequently develops into an embryo. After fertilization, the ovule develops a tough coat and turns into a seed, while the surrounding ovary ripens into a fruit.

96. What is the primary difference between external and internal fertilization? Why do animals with external fertilization produce larger numbers of eggs?

Ans :

External fertilization occurs outside the female's body, typically in water, where both parents release their gametes. Internal fertilization takes place inside the female's body, offering better protection for the egg. Animals exhibiting external fertilization, like frogs and fish, produce thousands of eggs because the gametes and developing embryos are highly vulnerable. A large number of these eggs are destroyed by water currents or eaten by predators. Producing offspring in massive quantities ensures that at least a few survive to adulthood.

- (B) The world's first surgical robotic device for blocking fallopian tubes
- (C) The world's first non-steroidal and non-hormonal oral contraceptive pill
- (D) A highly advanced, irritation-free copper IUD

Ans : (C)

Scientists at the Central Drug Research Institute (CDRI) in Lucknow made a major global breakthrough by developing the world's first non-steroidal and non-hormonal oral contraceptive pill. Designed to be taken just once a week, it is highly effective while avoiding common hormonal side effects like weight gain, nausea, or debilitating headaches.

VERY SHORT ANSWER

- 60.** Define vegetative propagation.

Ans :

Vegetative propagation is a type of asexual reproduction where new plants arise directly from the vegetative parts of a plant, like roots, stems, or leaves.

- 61.** What is the significance of asexual reproduction producing clones?

Ans :

It allows organisms to quickly produce genetically identical offspring in huge numbers, helping them rapidly increase their population under highly favourable environmental conditions.

- 62.** Name two common methods of vegetative propagation used in agriculture.

Ans :

Two common methods of vegetative propagation used efficiently in modern agricultural practices are cutting and grafting, which help propagate desirable plant varieties rapidly.

- 63.** Give one example of a plant that reproduces naturally through its leaves.

Ans :

Bryophyllum is an excellent example of a plant that reproduces vegetatively through tiny plantlets sprouting directly from the margins of its intact leaves.

- 64.** What is the role of spores in fungal reproduction?

Ans :

Spores are lightweight, microscopic reproductive bodies that easily float through air currents to germinate and quickly grow into new fungal individuals upon finding moisture.

- 65.** What is meiosis?

Ans :

Meiosis is a special type of cell division that reduces the chromosome number by half, specifically forming haploid gametes required for sexual reproduction.

- 66.** Why is meiosis essential for sexual reproduction?

Ans :

Meiosis halves the chromosome number in gametes, ensuring that the original diploid chromosome count is correctly restored when the male and female gametes fuse.

- 67.** State one difference between sepals and petals in a flower.

Ans :

Sepals primarily protect the delicate inner parts of the flower bud, whereas brightly coloured petals function specifically to attract various insects for successful pollination.

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- 68.** What is the female reproductive part of a flower composed of?

Ans :

The female part, called the pistil, is completely composed of three main structures: the sticky stigma at the top, the style, and the basal ovary.

- 69.** What is the immediate result of fertilisation in flowering plants?

Ans :

The direct result of fertilisation is the formation of a diploid cell called a zygote, which subsequently undergoes divisions to carefully develop into an embryo.

46. In 1978, a significant milestone in medical science was achieved in India regarding artificial reproduction. Who pioneered India's first test-tube baby through experimental in-vitro fertilisation (IVF)?

(A) Louis Pasteur
(B) P. Maheshwari
(C) Subhash Mukhopadhyay
(D) Gregor Mendel

Ans : (C)

Dr. Subhash Mukhopadhyay was a pioneering medical researcher who successfully delivered India's first test-tube baby, Kanupriya Agarwal (nicknamed Durga), in 1978. He achieved this remarkable feat through experimental In-Vitro Fertilisation (IVF), a sophisticated technique where an egg and sperm are combined outside the body in a specialized laboratory dish before implantation.

47. Identify the correct sequential order of events that occur when a sperm successfully meets an egg in the human female reproductive tract.

1. The zygote implants into the thickened inner lining of the uterus.
2. Millions of sperm enter through the vagina during sexual intercourse.
3. A sperm successfully fuses with the egg to form a zygote.
4. The zygote undergoes a series of mitotic divisions while travelling.
5. Sperm swim upwards through the reproductive tract to reach the oviduct.

(A) 2, 5, 3, 4, 1
(B) 5, 2, 3, 1, 4
(C) 2, 5, 4, 3, 1
(D) 3, 2, 5, 4, 1

Ans : (A)

The correct sequence begins with sperm entering the vagina (2) and swimming up to the oviduct (5). There, a single sperm fuses with the egg to create a zygote (3). This zygote immediately begins dividing mitotically as it travels down toward the uterus (4), where it finally implants into the nutrient-rich uterine lining (1).

48. What is the fundamental biological importance of the process called gametogenesis in human reproduction?

(A) It doubles the chromosome number in cells to provide extra genetic material.
(B) It involves mitosis to produce millions of genetically identical gametes.

- (C) It reduces the number of chromosomes to half, ensuring the offspring maintains the standard 46 chromosomes.
(D) It creates the thickened uterine lining required for immediate zygote implantation.

Ans : (C)

Gametogenesis is the specialized formation of gametes in the testes and ovaries. It is fundamentally important because it utilizes meiosis, which reduces the diploid chromosome number by exactly half (from 46 to 23). When these haploid gametes fuse during fertilisation, they correctly restore the normal 46 chromosomes in the newly formed individual.

Match the key stages of a typical 28-day menstrual cycle in List-I with their corresponding events in List-II.

List-I (Cycle Stage)		List-II (Event)	
P.	Day 1–5	1.	Ovary releases a mature egg
Q.	Day 6–14	2.	Shedding of uterine lining (Menstruation)
R.	Day 14	3.	Uterine lining becomes thicker and rich with blood vessels
S.	Day 15–28	4.	Uterine lining gradually rebuilds while egg starts maturing

(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-1, S-2

Ans : (A)

During Days 1–5 (P), menstruation occurs as the old lining sheds (2). From Days 6–14 (Q), the lining rebuilds while a new egg matures (4). Around Day 14 (R), ovulation happens with the release of the egg (1). From Days 15–28 (S), the lining thickens further to prepare for potential pregnancy (3).

50. **Assertion (A):** If the released egg is not fertilised, the inner lining of the uterus breaks down and leaves the body as blood and mucus.

Reason (R): The thickened, blood-rich uterine lining is no longer required to nourish a developing zygote.

82. What is the relationship between a pregnant mother's diet and her baby's health?

Ans :

A pregnant mother requires a properly balanced daily diet to directly supply all essential vitamins, critical minerals, and vital proteins needed for rapid baby growth.

83. Give one practical use of using barrier methods like condoms.

Ans :

Condoms physically prevent active sperm from reaching the egg to avoid pregnancy, while simultaneously offering crucial protection against highly dangerous sexually transmitted infections during intimacy.

84. Name two infections that can be transmitted sexually.

Ans :

Two common sexually transmitted infections that can easily pass from an infected person to a healthy partner during close sexual contact are gonorrhoea and syphilis.

85. What is the full form and function of an IUD?

Ans :

An IUD specifically stands for Intrauterine Device, which is a highly effective contraceptive securely placed inside the female uterus to successfully prevent any unwanted pregnancies.

86. What is the principle behind oral contraceptive pills?

Ans :

Oral contraceptive pills primarily work by deliberately altering the female body's internal hormone levels, which successfully stops the ovaries from releasing mature eggs for fertilisation.

87. State one key characteristic of emotional maturity during human adolescence.

Ans :

Emotional maturity during human adolescence is prominently characterised by a developing ability to handle complex feelings responsibly, communicate clearly, and deliberately make highly thoughtful decisions.

88. Who proved that life comes from pre-existing life and what theory did it strengthen?

Ans :

Louis Pasteur scientifically proved that living things always arise directly from previously existing life, which strengthened the cell theory and heavily influenced essential sterilisation practices.

89. What is an angiosperm?

Ans :

Angiosperms are an incredibly diverse group of flowering plants naturally existing on Earth, primarily characterised by their highly specific ability to reproduce sexually using flowers.

SHORT ANSWER QUESTIONS

90. Explain vegetative propagation with an example. How is it helpful in agriculture?

Ans :

Vegetative propagation is an asexual reproduction method where new plants arise from vegetative parts like roots, stems, or leaves, without producing seeds. For example, sprouting of potato tubers or ginger rhizomes. In agriculture, this method is highly helpful because it allows farmers to rapidly cultivate large numbers of genetically identical crops. It ensures desirable traits are preserved and helps in growing plants that do not produce viable seeds, like bananas, efficiently and on a large scale.

91. Describe the process of budding in hydra. Why are the offspring produced called clones?

Ans :

In hydra, repeated cell division at a specific site on the parent body produces a small outgrowth called a bud. This bud gradually enlarges, develops necessary body parts, and eventually detaches from the parent's body to live independently. The offspring produced through this method are called clones because the central process involved is mitosis, a type of cell division that maintains the exact same number of chromosomes. Thus, the resulting hydra are genetically identical to the parent.

- 70.** What would happen if pollen transfer fails to occur in a flower?

Ans :

If successful pollen transfer fails to occur entirely, fertilisation cannot take place, meaning the plant will be completely unable to produce any seeds or fruits.

- 71.** How is self-pollination different from cross-pollination?

Ans :

Self-pollination occurs when pollen strictly transfers within the exact same plant, whereas cross-pollination involves successfully transferring pollen to the stigma of a completely different plant.

- 72.** Where does external fertilisation typically take place?

Ans :

External fertilisation normally takes place entirely outside the female body, usually in an aquatic environment where organisms freely release their massive quantities of gametes.

- 73.** What is the main advantage of internal fertilisation?

Ans :

Internal fertilisation provides high protection for the developing zygote safely inside the female body, significantly increasing overall survival chances of the vulnerable growing embryo.

- 74.** Why do fish and frogs produce huge numbers of eggs?

Ans :

They naturally produce massive numbers of eggs because external fertilisation leaves eggs fully exposed, and many are inevitably destroyed by water currents or hungry predators.

- 75.** What is the primary function of the human testes?

Ans :

The human testes primarily function to produce male gametes known as sperm, and they secrete essential hormones that regulate important male reproductive physical changes.

- 76.** Where are the testes located in the human body and why?

Ans :

The testes are securely located entirely outside the abdominal cavity within the scrotum to meticulously maintain lower temperatures strictly necessary for continuous sperm production.

- 77.** Describe the overall structure of the human uterus briefly.

Ans :

The human uterus is a highly muscular, expandable internal structure shaped like a bag, designed specifically to securely hold and continuously nourish the growing foetus.

- 78.** What happens when a human egg is successfully fertilised?

Ans :

The successfully fertilised egg quickly forms a distinct zygote, which repeatedly divides to gradually become a multicellular embryo that eventually implants into the uterine lining.

- 79.** Define ovulation.

Ans :

Ovulation is the vital biological process where a fully mature egg is periodically released from one of the female ovaries, usually occurring once every month.

- 80.** What causes menstruation in human females?

Ans :

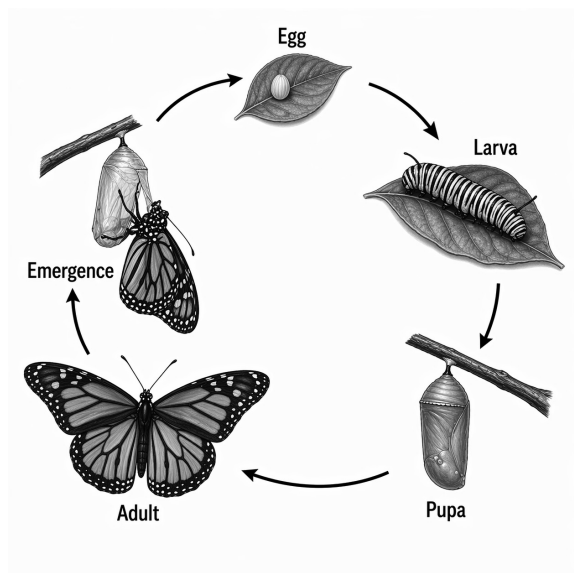
Menstruation is directly caused by the breakdown and shedding of the thickened inner uterine lining along with blood when the released egg remains completely unfertilised.

- 81.** What is the scientific term used for the developing baby inside the womb from the ninth week onward?

Ans :

From the ninth week of pregnancy onward, the rapidly developing human baby safely inside the protective mother's womb is scientifically referred to as a foetus.

97. Study the life cycle diagram. What is the role of the larval stage in this life cycle? Why is this feeding stage crucial?



Ans :

The larval stage, often seen as a caterpillar, is primarily an intermediate feeding stage in the development of organisms like butterflies. These animals hatch from eggs containing relatively small amounts of yolk, which is only enough to form the larva. The larva must then obtain its own nutrition by heavily feeding on organic matter, such as leaves. This intense feeding allows it to accumulate enough nutrients and energy required to undergo the dramatic transformation inside the pupa into an adult butterfly.

98. Describe the journey of an unfertilised egg in the human female reproductive system from its release to its exit.

Ans :

Once a month, an ovary releases a mature egg during a process called ovulation. This egg enters the oviduct (fallopian tube) and travels towards the uterus. If the egg is not fertilised by a sperm, it remains viable for about a day before it degenerates. The thick, blood-rich inner lining of the uterus, which was prepared to receive a zygote, is no longer needed. Consequently, this uterine lining breaks down and sheds, exiting the body through the vagina as blood and mucus during menstruation.

99. How do human male and female gametes differ in terms of size and motility? Where are they produced?

Ans :

Human male gametes (sperm) are very small in size and are highly motile; they possess a long tail that allows them to swim actively towards the egg. They are produced in the testes in large millions. In contrast, female gametes (eggs) are much larger as they contain stored nutrients to nourish a developing embryo. Eggs are non-motile and are produced in the ovaries, with usually only one mature egg released per month.

100. Why does the uterine lining become thick and spongy every month in human females? What happens if fertilization does occur?

Ans :

The uterine lining becomes thick, spongy, and rich in blood vessels every month as a preparatory measure to receive and support a developing embryo. Following ovulation, the body anticipates a potential pregnancy. If fertilization does occur, the newly formed zygote undergoes division and implants itself into this thickened lining. The rich blood supply of the uterus provides essential nourishment and oxygen to the growing embryo, and the lining remains intact throughout the pregnancy, causing menstruation to stop.

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101. Describe the sequence of events in humans starting from the entry of sperm into the female body up to implantation.

Ans :

During sexual intercourse, millions of sperm enter through the vagina and actively swim upward through the reproductive tract, reaching the oviduct. Here, if a sperm encounters an egg, it fuses with it to form a single-celled zygote, marking fertilization. This zygote begins to divide repeatedly through mitotic divisions to form a multicellular embryo while continuing its journey down the oviduct towards the uterus. Finally, the embryo embeds itself deeply into the thickened, nutrient-rich inner lining of the uterus, a process known as implantation.

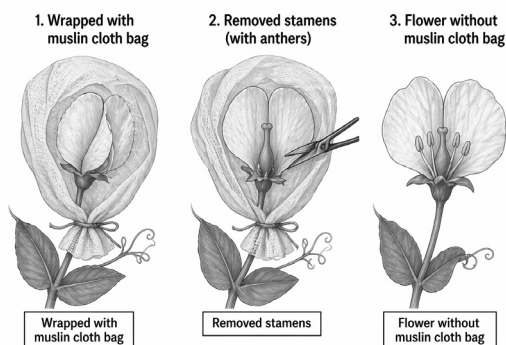
- 102.** Suppose a farmer grows a crop that only produces flowers entirely enclosed within their petals, never opening. What type of pollination will occur and how will it affect genetic diversity?

Ans :

If the flowers remain completely closed, cross-pollination is impossible because external pollen cannot enter, and internal pollen cannot escape. Only self-pollination will occur, as the pollen from the anther will directly fall onto the stigma of the same enclosed flower. Over several generations, this exclusive self-pollination will severely reduce the genetic diversity of the crop. The plants will become genetically highly similar, producing offspring that are less adaptable to environmental changes and more vulnerable to diseases.

- 103.** Draw the experimental setup used to demonstrate the necessity of pollen transfer in pea plants. What is the purpose of the muslin cloth bags?

Ans :



The primary purpose of using muslin cloth bags in this pollination experiment is to control the reproductive environment by preventing unwanted, external pollen from reaching the stigma of the flower. By securely bagging the flower, one can completely stop cross-pollination by wind or insects. This allows researchers to isolate specific variables, such as observing whether a flower can self-pollinate and form a fruit on its own, or what happens when its stamens are entirely removed and external pollen is blocked.

- 104.** Explain the artificial hybridization technique used by farmers for selective breeding of plants.

Ans :

Artificial hybridization is a controlled plant breeding technique used to combine desirable

traits from different plants. First, the farmer carefully removes the stamens from the flowers of the selected female parent plant before they mature to prevent self-pollination. This flower is then covered with a bag. Later, pollen from another plant possessing the desired characters is manually dusted onto the stigma of the bagged flower. This ensures that the resulting seeds will grow into hybrid plants with the specific qualities chosen by the farmer.

- 105.** Compare the reproductive strategies of wind-pollinated plants and insect-pollinated plants with respect to pollen production and flower characteristics.

Ans :

Wind-pollinated plants, such as maize and wheat, produce extremely large quantities of light, small pollen grains to ensure some reach their target by chance. Their flowers are usually inconspicuous with long, feathery stigmas to trap pollen. In contrast, insect-pollinated plants, like sunflowers and hibiscus, produce significantly fewer pollen grains that are sticky or spiny to attach to insects. Their flowers are typically brightly coloured, fragrant, and produce nectar to actively attract insect pollinators.

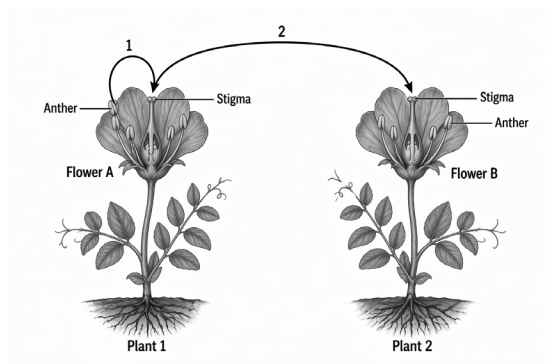
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- 106.** A teenager claims that physical maturity during puberty implies complete readiness for reproduction and parenthood. Do you agree? Justify.

Ans :

No, I strongly disagree with this claim. While puberty initiates physical sexual maturation, meaning the body begins producing gametes (sperm or eggs) and becomes physically capable of reproduction, this is only one aspect of development. Emotional, mental, and social maturity take much longer to achieve. Readiness for parenthood requires a deep understanding of responsibilities, emotional stability to handle complex feelings, and the ability to make thoughtful decisions, none of which automatically arrive with physical changes.

107. Study the given diagram showing pollen transfer. Identify processes 1 and 2. Give an example of an agent that facilitates process 2.



Ans :

Process 1 represents self-pollination, as the pollen grain is transferred from the anther to the stigma of the exact same flower. Process 2 represents cross-pollination, where pollen is transferred from the anther of a flower on one plant to the stigma of a flower on a different plant of the same species. External agents are required to facilitate process 2. Examples of such pollinating agents include wind blowing the pollen, or insects like bees carrying it on their bodies.

108. What is the normal duration of human pregnancy, and how is it divided? What changes happen to the foetus in the first phase?

Ans :

The normal duration of a human pregnancy is approximately nine months, which is medically divided into three stages known as trimesters. During the first trimester, representing the initial three months, the most critical foundational developments occur. The fertilized egg transforms into an embryo and then into a foetus. It is during this crucial first phase that major internal organs start forming and developing rapidly, laying the essential groundwork for the baby's future growth in subsequent trimesters.

109. Explain the technique of tissue culture in plants. Why is it considered an important agricultural advancement?

Ans :

Tissue culture is an advanced vegetative propagation technique where new plants are grown from small pieces of plant tissue, typically the

shoot tip, in a sterile nutrient-rich medium. It is an extremely important agricultural advancement because it allows for the rapid mass production of mature plants. More importantly, using the apical meristem ensures that the resulting plantlets are completely free from viral infections. It provides farmers with guaranteed healthy, high-yielding crops like bananas, significantly boosting agricultural productivity.

110. What are Sexually Transmitted Infections (STIs)? State two ways they can be prevented.

Ans :

Sexually Transmitted Infections (STIs) are infectious diseases that are passed from an infected individual to an uninfected person primarily through intimate physical sexual contact. Common examples include gonorrhea, syphilis, and HIV/AIDS. These infections can be prevented by adopting safe sex practices. Using barrier methods of contraception, specifically condoms, during sexual activity creates a physical block that prevents the exchange of bodily fluids, significantly reducing transmission risk. Additionally, responsible decision-making and awareness are crucial for prevention.

111. Why is a tomato technically considered a fruit, even though it is commonly used as a vegetable in cooking?

Ans :

In biological terms, a fruit is the mature, ripened ovary of a flower, containing the seeds that developed from fertilized ovules. A tomato develops directly from the ovary at the base of the tomato flower's pistil after successful pollination and fertilization. If you cut a tomato open, you can clearly see the seeds enclosed within the fleshy tissue. Therefore, scientifically, because it originates from the flower's ovary and bears seeds, a tomato is classified as a fruit.

112. Why is reproduction considered an essential biological process even though an individual organism can survive without it?

Ans :

While functions like respiration and digestion are vital for the survival of an individual organism, reproduction is not strictly necessary for an individual's own life. However, it is an essential biological process for the survival of the entire

QUESTIONS:

- (a) What is the pear-shaped, bag-like organ called, and what event marks the beginning of pregnancy in this organ?
- (b) What is the process of releasing a mature egg halfway through the cycle called, and roughly on which day of a typical 28-day cycle does it occur?
- (c) What is the scientific term for the breakdown and exit of the thickened lining and blood, and how long does this phase usually last?

Ans :

- (a) The organ is called the uterus. The beginning of pregnancy is marked by implantation, which is when the developing zygote embeds into the thickened inner lining of the uterus.
- (b) The process is called ovulation, and it typically occurs around the 14th day of a 28-day menstrual cycle.
- (c) The scientific term is menstruation. This shedding phase usually lasts for 3 to 7 days.

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- 138.** A local health worker, Sunita, conducts a community awareness camp for young adults. She discusses the responsibilities of sexual maturity, emphasizing that physical readiness does not equal emotional readiness. Sunita highlights the importance of safe practices, warning the audience about severe infections that can spread through close physical contact. She displays various family planning tools, specifically pointing out a simple barrier device that is unique because it not only prevents unwanted pregnancies by blocking sperm from reaching the egg but also serves as the primary defense against these serious infections.

QUESTIONS:

- (a) Explain the difference between physical sexual maturity and emotional maturity as discussed by Sunita.
- (b) What are the severe infections spread through close physical contact called? Give any two examples.
- (c) Name the specific barrier device Sunita is pointing out that offers dual protection.
- (d) Apart from barrier methods, name one intra-uterine device (IUD) used to avoid pregnancy and state a potential drawback of its use.

Ans :

- (a) Physical sexual maturity means the body is capable of reproduction (producing gametes). Emotional maturity takes longer and involves handling feelings, communicating clearly, and making thoughtful, responsible decisions.
- (b) These infections are called Sexually Transmitted Infections (STIs). Examples include gonorrhoea, syphilis, herpes, genital warts, and HIV/AIDS.
- (c) The barrier device offering dual protection is the condom.
- (d) An example of an intra-uterine device is the copper-T. A potential drawback is that it may sometimes irritate the uterus and cause discomfort.

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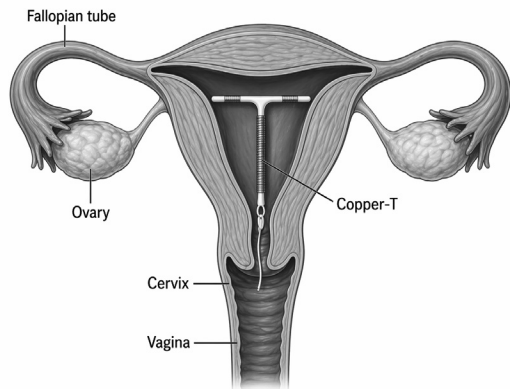
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118. Draw a diagram of an Intra-Uterine Device (IUD). How do devices like the Copper-T help in preventing unwanted pregnancies?

Ans :



Intra-Uterine Devices (IUDs) like the Copper-T are highly effective contraceptive methods placed directly inside the uterus by a healthcare professional. They work primarily by preventing fertilization and implantation. The copper ions released by the device are toxic to sperm, significantly decreasing their motility and ability to fertilize an egg. Even if fertilization somehow occurs, the physical presence of the IUD alters the uterine lining, making it highly unsuitable for the embryo to implant, thus safely preventing pregnancy.

LONG ANSWER QUESTIONS

119. (a) What is vegetative propagation?
 (b) Describe the process of grafting with a suitable example.
 (c) Why is the tissue culture technique considered a revolutionary advancement in agriculture?

Ans :

- (a) Vegetative propagation is an asexual reproduction method where new plants develop from vegetative parts like stems, roots, or leaves, involving only a single parent.
 (b) Grafting is an artificial propagation method where a stem piece (scion) from a desired plant is attached to the healthy rooted stem (stock) of another plant. A slit is made, the pieces are fitted together, and tightly wrapped

to prevent pest entry. They heal and grow as one plant, for example, grafting a yellow rose stem onto a wild pink rose base to combine desirable traits.

- (c) Tissue culture is revolutionary because it allows farmers to grow thousands of exact plant copies from a tiny piece of apical meristem tissue in a sterile laboratory environment. This ensures the mass production of disease-free, high-yielding varieties, such as in banana farming, efficiently bypassing traditional slower methods.

120. (a) What is meiosis and where does it occur in the human body?
 (b) Why is this specific type of cell division absolutely essential for sexual reproduction?
 (c) Explain how meiosis contributes to the long-term survival of a species.

Ans :

- (a) Meiosis is a specialised type of cell division that reduces the chromosome number of a parent cell by half, resulting in the formation of haploid daughter cells. In the human body, it occurs in the reproductive organs—the testes in males and the ovaries in females—to produce gametes (sperm and eggs).
 (b) Meiosis is absolutely essential for sexual reproduction because it ensures that when a male and female gamete fuse during fertilisation, the resulting zygote restores the original diploid chromosome number (46 in humans). Without meiosis, the chromosome count would double in every generation, leading to biological collapse.
 (c) Furthermore, meiosis involves the random mixing and segregation of chromosomes. This creates unique genetic combinations in every gamete, leading to genetic variation among offspring. This variation helps individuals adapt to changing environments, driving evolution and ensuring the long-term survival of the species.

121. (a) Differentiate between external and internal fertilisation with examples.
 (b) Why do animals exhibiting external fertilisation typically produce a significantly larger number of eggs than those using internal fertilisation?
 (c) Explain the role of yolk in developing embryos of fishes and insects.

weeks to check if fruits would develop in place of the flowers.

QUESTIONS:

- (a) Why did the students wrap the flower buds in muslin cloth bags?
- (b) Predict whether Bud A will develop into a fruit. Justify your answer.
- (c) Will Bud B be able to produce a fruit? If yes, through which specific process?
- (d) What is the main function of the stamens that were removed from Bud A?

Ans :

- (a) The students wrapped the buds in muslin cloth bags to prevent unwanted pollen grains from external sources (cross-pollination) from reaching the stigma of the flowers.
- (b) Bud A will not develop into a fruit. Since its stamens were removed and it was covered, no pollen could reach its stigma, meaning fertilisation cannot take place.
- (c) Yes, Bud B will likely produce a fruit. Since its stamens were left intact inside the bag, pollen from its own anthers can fall onto its stigma, leading to self-pollination and subsequent fertilisation.
- (d) The main function of the stamen, which is the male reproductive part, is to produce pollen grains that contain the male gametes necessary for reproduction.

- 133.** An agricultural research center maintains two large fields side by side. Field X grows maize, which produces massive quantities of tiny, lightweight, and dry pollen grains, though its flowers lack bright petals and nectar. Field Y grows sunflowers, featuring large, vibrant yellow petals and heavy, sticky pollen. Recently, aggressive pesticide use in a nearby village caused a severe drop in the local butterfly and bee populations. Within a few weeks, scientists noticed a massive decline in seed formation in one field, while the other remained largely unaffected.

QUESTIONS:

- (a) Which field (X or Y) experienced a severe decline in seed formation and why?
- (b) What is the pollinating agent for the crop in Field X, and how is its pollen adapted for this?
- (c) Explain why producing extremely large numbers of pollen grains is an effective and necessary strategy for the plants in Field X.

Ans :

- (a) Field Y (sunflowers) experienced a severe decline. Sunflowers rely on insects like bees and butterflies for cross-pollination. The pesticide reduced insect populations, preventing pollen transfer.
- (b) The pollinating agent for Field X (maize) is the wind. Its pollen is adapted by being very small, lightweight, and dry, allowing it to be easily carried by air currents.
- (c) Wind pollination is a highly random and undirected process. A large portion of the pollen blows away and never reaches a female flower. Producing millions of pollen grains increases the probability that at least some will successfully land on a compatible stigma.

- 134.** During a biology practical, a teacher showed a microscopic video of plant reproduction. The students watched a tiny yellow grain land on the sticky, flattened top of a female floral part. Suddenly, a long tube began to sprout from the yellow grain, pushing its way downwards through a long neck-like passage. The tube eventually reached a swollen base at the bottom, delivering its contents to fuse with a tiny egg cell located inside a small compartment. The teacher explained this fusion is the beginning of a new plant life.

QUESTIONS:

- (a) Identify the sticky flattened top, the long neck-like passage, and the swollen base of the female floral part.
- (b) What is the yellow grain, and what is the tube growing from it called?
- (c) Name the process of fusion between the contents of the tube and the egg cell. What is the newly formed cell called?
- (d) What will the swollen base and the tiny egg compartments eventually develop into after this process is complete?
- (e) Mention two common agents that help in the dispersal of the final reproductive structures in nature.

Ans :

- (a) The sticky flattened top is the stigma, the long neck-like passage is the style, and the swollen base is the ovary.
- (b) The yellow grain is a pollen grain, and the tube growing from it is the pollen tube.
- (c) The fusion process is called fertilisation. The newly formed cell is called a zygote.

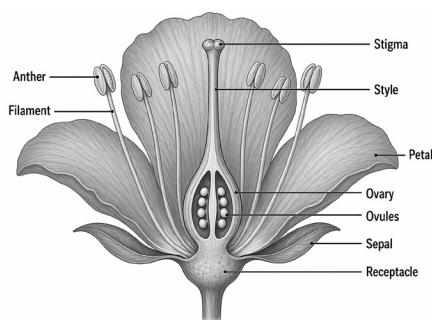
Ans :

- (a) The testes are oval-shaped primary reproductive organs that perform two critical functions: producing millions of male germ cells called sperm and secreting testosterone, the hormone regulating sperm production and pubertal changes. The vas deferens is a muscular tube that acts as a secure transport pathway, carrying mature sperm from the testes towards the urethra. Along this route, the prostate gland, along with seminal vesicles, secretes nutrient-rich fluids. These fluids mix with sperm to provide nourishment and facilitate their active swimming motion.
- (b) Structurally, sperm and eggs differ significantly. A sperm is extremely small, actively motile using its long tail, and contains absolutely no stored nutrients. In stark contrast, a human egg (ovum) is relatively very large, completely non-motile, and contains a significant amount of stored nutrients to support early embryonic development immediately following fertilisation.

125. (a) Draw a longitudinal section of a flower showing its various parts and clearly label the male and female reproductive organs.
- (b) Trace the sequence of events that occur from the moment a compatible pollen grain lands on the stigma until a seed is formed.

Ans :

(a)



- (b) Once a compatible pollen grain successfully lands on the sticky stigma through pollination, a remarkable process is initiated. The pollen grain germinates and produces a slender pollen tube that actively grows downwards through the style to reach the ovary. This tube carries the male gamete safely towards the ovule. Upon reaching the

ovule, the male gamete fuses with the female gamete (egg cell) residing inside. This fusion process is called fertilisation, and it results in the formation of a single-celled zygote. The zygote subsequently undergoes multiple cell divisions to develop into a multicellular embryo. Concurrently, the protective layers of the ovule harden, and the entire ovule transforms into a mature seed containing the dormant embryo. Meanwhile, the surrounding ovary undergoes rapid enlargement and eventually ripens into a fruit, while other floral parts generally wither and fall off.

126. (a) What are Sexually Transmitted Infections (STIs)?
- (b) State two methods of contraception that protect against STIs and two methods that do not.
- (c) Explain the mechanisms by which Intra-Uterine Devices (IUDs) and surgical methods prevent unwanted pregnancies.

Ans :

- (a) Sexually Transmitted Infections (STIs) are infectious diseases transmitted from an infected person to an uninfected person primarily through close physical contact during sexual activity. Common examples include HIV, gonorrhoea, and syphilis.
- (b) Barrier methods like male and female condoms are highly effective at preventing pregnancy while simultaneously protecting against STIs. Conversely, oral contraceptive pills and Intra-Uterine Devices (IUDs) only prevent pregnancy and offer zero protection against STIs.
- (c) IUDs, such as the Copper-T, are safely placed inside the uterus by a doctor. They act by irritating the uterine lining and releasing copper ions, which severely reduce sperm motility and survival, preventing fertilisation. Surgical methods offer a permanent solution by physically blocking gamete transport. In males, blocking the vas deferens prevents sperm release, while in females, blocking the fallopian tubes prevents the egg and sperm from ever meeting, ensuring absolute contraception.

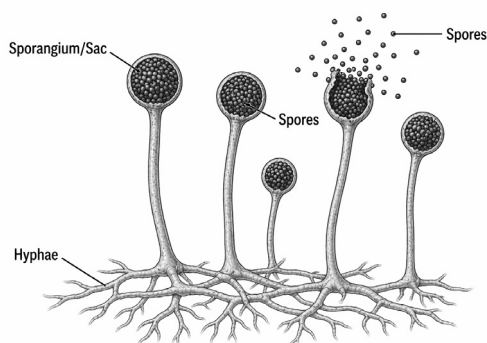
Ans :

- (a) External fertilisation occurs outside the female body, typically in aquatic environments where both parents release gametes into the water (e.g., frogs, fishes). Internal fertilisation takes place safely inside the female body (e.g., birds, humans).
- (b) Animals using external fertilisation must produce hundreds or thousands of eggs simultaneously. This is because eggs and sperm released in open water are highly vulnerable to being washed away by water currents, destroyed by harsh environmental conditions, or eaten by predators. Producing a massive quantity ensures statistically that at least a few offspring survive to adulthood.
- (c) In fishes, amphibians, and insects, the mother's body does not provide continuous nourishment after egg-laying. Therefore, the egg contains yolk, a vital nutritive substance that fuels the initial development of the embryo. It provides just enough energy for the embryo to hatch into an independent, feeding larva.

- 122.** (a) Draw a labelled diagram of *Rhizopus* showing spore formation.
- (b) How does this asexual method help the organism survive and spread rapidly?
- (c) Why does refrigeration effectively prevent the spoilage of food by such microbes?

Ans :

(a)



- (b) Spores are microscopic, lightweight reproductive units produced in huge numbers inside a sac-like structure called a sporangium. Because they are extremely light, spores can easily float through air currents and spread over large distances. When they land on a

moist surface, they quickly germinate into new fungal individuals. This allows the organism to rapidly colonise new areas and exponentially increase its population. Furthermore, spores often possess protective walls enabling them to survive harsh environmental conditions until favourable conditions return.

- (c) Refrigeration is a highly effective method to prevent food spoilage because spores require specific optimal conditions—namely warmth and moisture—to germinate and grow. By significantly lowering the temperature, refrigerators create an unfavourable, cold environment that drastically slows down or completely stops the metabolic activity and reproduction of these fungal spores, thus preserving the food longer.

- 123.** (a) What is menstruation and why does it occur in human females?
- (b) Trace the key biological changes that take place in the uterus and ovaries during a typical 28-day menstrual cycle.

Ans :

- (a) Menstruation is the monthly shedding of the thickened inner lining of the uterus, accompanied by bleeding through the vagina. It occurs when a released egg is not fertilised by a sperm, rendering the prepared uterine bed unnecessary.
- (b) The cycle spans roughly 28 days. From Days 1 to 5, menstruation happens as the old lining breaks down. Between Days 6 and 14, the uterus gradually rebuilds a new, blood-rich inner lining, while an egg simultaneously matures inside one of the ovaries. Around Day 14, ovulation occurs as the ovary releases this mature egg. From Days 15 to 28, the uterine lining thickens further in anticipation of receiving a fertilised embryo. If fertilisation fails to happen, the egg degrades within a day, hormone levels drop, and the thickened lining eventually breaks apart on the 28th day, restarting the menstrual cycle.

- 124.** (a) Describe the distinct roles of the testes, vas deferens, and prostate gland in the human male reproductive system.
- (b) Compare a human sperm and an egg based on their size, motility, and stored nutrients.

- (c) The central biological process behind this asexual reproduction is mitosis. Because it involves only one parent for the shoot system, the new yellow roses produced will be genetically identical to the parent yellow rose plant, acting as clones.

130. Before leaving for a week-long family vacation, Rahul accidentally left a slightly moist piece of homemade roti inside a dark steel container on the kitchen counter. When he returned and opened the container, he was surprised to see fuzzy black and grey patches completely covering the roti. Intrigued, he took a small sample to his school laboratory. Under the microscope, he observed a network of thread-like structures with tiny, round sacs at their tips, which contained thousands of minute spherical bodies waiting to be released into the air.

QUESTIONS:

- Identify the organism growing on the roti and the specific mode of asexual reproduction it uses.
- What are the thread-like structures and the tiny round sacs at their tips called?
- Why did the organism grow so rapidly on the roti inside the closed steel container?
- How did the organism originally reach the freshly made roti before Rahul left for his vacation?

Ans :

- The organism is bread mould (a type of fungus like *Rhizopus*), and it reproduces asexually through spore formation.
- The thread-like structures are called fungal hyphae, and the tiny round sacs at their tips are called sporangia (or spore sacs).
- The organism grew rapidly because the dark, warm, and moist environment inside the steel container provided highly favorable conditions for the spores to germinate and multiply quickly.
- Spores of the mould are extremely lightweight and float easily through air currents. They were already present in the kitchen air and settled on the moist roti before the container was closed.

131. During a science exhibition, 14-year-old Aman was looking at a family photograph. He noticed that while he shares his father's black hair and his mother's brown eyes, he looks quite different from his younger sister, who has blonde hair and blue eyes. His biology teacher explained that although human cells generally contain a fixed number of chromosomes, the cells responsible for reproduction undergo a special type of division. This unique division ensures that the chromosome number does not double in every generation and creates a random mixing of genetic traits.

QUESTIONS:

- Name the special type of cell division that forms reproductive cells.
- How many chromosomes are present in a normal human body cell compared to a human reproductive cell?
- What are the male and female reproductive cells (gametes) called in humans?
- Compare the human male and female gametes based on their size and motility.
- Why is the variation created by this cell division important for a species?

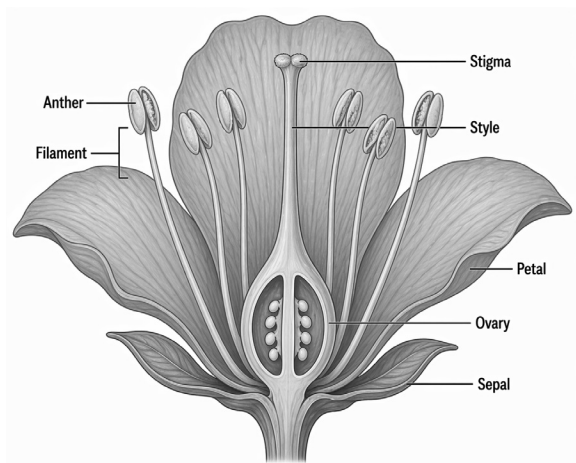
Ans :

- The special type of cell division is called meiosis.
- A normal human body cell contains 46 chromosomes, whereas a human reproductive cell (gamete) contains half that number, which is 23 chromosomes.
- The male gametes are called sperm, and the female gametes are called eggs (or ova).
- Human male gametes (sperm) are very small and actively motile (moving). In contrast, female gametes (eggs) are much larger and non-motile.
- Variation helps some individuals within a population adapt better to changing environments, ensuring the long-term survival and evolution of the species.

132. A group of students decided to conduct an experiment on garden pea plants in their school greenhouse. They selected two juvenile flower buds on the same plant. For the first bud (Bud A), they carefully removed all the stamens and wrapped it loosely in a muslin cloth bag. For the second bud (Bud B), they left all the parts intact but also wrapped it tightly in a muslin cloth bag. They observed both buds regularly for several

species. Every organism has a definite lifespan and will eventually die. Reproduction ensures the continuous production of new individuals of the same kind, replacing those that perish. Without reproduction, a species would eventually go extinct and life on Earth would cease to exist.

113. Study the given diagram of a flower. Identify the male and female reproductive parts. What are their respective components?



Ans :

The male reproductive part of the flower is called the stamen, and the female reproductive part is called the pistil. The stamen consists of two main components: a slender stalk known as the filament and a swollen tip called the anther, which produces pollen grains containing male gametes. The pistil has three parts: the stigma, which is the sticky top surface to receive pollen; the style, a long tube; and the ovary, a swollen base containing ovules with female gametes.

114. What is the genetic significance of meiosis in gamete formation? How does it lead to variation in offspring?

Ans :

Meiosis is genetically significant because it halves the chromosome number, producing haploid gametes. This ensures that when sperm and egg fuse during fertilization, the resulting zygote restores the specific diploid chromosome number of that species. Furthermore, meiosis introduces immense genetic variation. During the process, chromosomes from both parents randomly mix and segregate, creating entirely unique combinations of traits in the gametes. Consequently, offspring inherit a unique blend of characteristics, making

them genetically different from both their parents and siblings.

115. Detail the step-by-step process of grafting used to combine two different plant varieties.

Ans :

Grafting starts by selecting a healthy rooted plant (Plant A) and a desired stem piece from another plant (Plant B). A wound or precise slit is carefully created on a twig of Plant A. The cutting from Plant B is then tightly inserted and fitted into this slit. The joined area is securely protected by wrapping it with cotton cloth or a grafting film to prevent pests and retain moisture until it heals. With regular watering, Plant B eventually grows integrated with Plant A.

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116. What would happen to the population of frogs if a factory started releasing mildly toxic chemicals into their breeding pond that specifically hardened the outer layer of their eggs?

Ans :

Frogs rely on external fertilization in water, where the male releases sperm over the eggs laid by the female. If a chemical hardened the outer jelly-like layer of the eggs immediately upon release, the sperm would be completely unable to penetrate the eggs. Consequently, fertilization would fail to occur entirely. Since frogs produce many eggs because survival rates are normally low, zero fertilization would rapidly cause a catastrophic collapse in the frog population in that specific area.

117. Describe the importance of maternal care and nutrition immediately after childbirth.

Ans :

Immediately after childbirth, the newborn baby requires immense care and specific nutrition for healthy development. Breast feeding is essential as the mother's milk provides complete, easily digestible nutrition and crucial antibodies that protect the infant from many diseases. Additionally, the newborn must be kept warm and vaccinated on time. The mother's well-being is equally critical; she requires highly nutritious food, adequate rest, and strong emotional support from her family to recover physically and avoid conditions like post-partum depression.

- (d) The swollen base (ovary) will develop into a fruit, and the tiny egg compartments (ovules) will develop into seeds.
- (e) Seed dispersal commonly takes place by wind, water, or animals.

135. A nature documentary contrasts the life cycles of two different animals. First, it shows a female salmon fish in a shallow stream releasing thousands of soft, transparent eggs directly into the water, while a male salmon swims over them, releasing a cloudy fluid. Next, the camera moves to a nearby tree where a female pigeon lays just two hard-shelled eggs in a carefully woven nest. The narrator explains that the pigeon's eggs were already fertilized deep inside her body before the protective shells were formed around them.

QUESTIONS:

- (a) Differentiate between the modes of fertilisation exhibited by the salmon fish and the pigeon.
- (b) Why does the salmon fish need to produce thousands of eggs while the pigeon produces only two?
- (c) Where does the developing embryo inside the pigeon's egg get its nutrition from?
- (d) Which of the two animals ensures a higher estimated survival rate of its young ones and why?

Ans :

- (a) The salmon fish exhibits external fertilisation, where gametes fuse outside the body in water. The pigeon exhibits internal fertilisation, where gametes fuse inside the female's body.
- (b) The salmon produces thousands of eggs because many are destroyed by water currents or eaten by predators, so a large number ensures at least a few survive. The pigeon produces fewer eggs because internal fertilisation and hard shells offer better protection.
- (c) The developing embryo inside the pigeon's egg gets its nutrition from the yolk, which contains nutritive substances stored specifically to nourish it until it hatches.
- (d) The pigeon ensures a higher survival rate. Internal fertilisation, protective eggshells, and parental care in a nest protect the offspring from harsh environmental conditions and predators compared to the unprotected fish eggs in open water.

136. Dr. Mehta is counseling a young couple about reproductive biology using anatomical charts. He points to a diagram of the male system, highlighting two oval-shaped structures resting in a pouch outside the main body cavity, explaining their critical role in generating millions of motile cells and hormones. He then switches to the female chart, tracing how a single mature egg is released from one of the almond-shaped organs each month. The egg then travels into a narrow, funnel-like tube where it waits to potentially meet the male gametes.

QUESTIONS:

- (a) Name the oval-shaped structures in the male body and the pouch they rest in.
- (b) Why are these male reproductive structures located in a pouch outside the main abdominal cavity?
- (c) Identify the almond-shaped organs in the female that produce the egg, and the narrow tube the egg travels into.
- (d) How do the secretions from glands like the seminal vesicles and prostate assist the male gametes?

Ans :

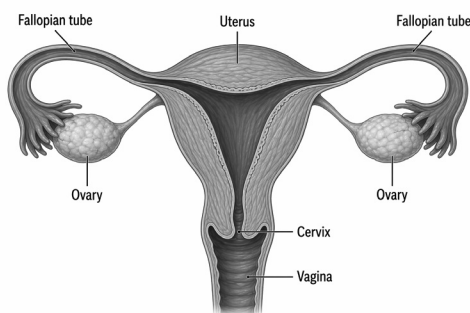
- (a) The oval-shaped structures are the testes, and they rest in a pouch called the scrotum.
- (b) They are located outside the abdominal cavity because the scrotum keeps the testes at a temperature slightly cooler than normal body temperature, which is necessary for the proper production of sperm.
- (c) The almond-shaped organs are the ovaries, and the narrow tube the egg travels into is the oviduct (or fallopian tube).
- (d) The secretions from the seminal vesicles and prostate gland add nourishing fluids that help the sperm remain active and make it easier for them to move and swim towards the egg.

137. Anita attended an adolescent health seminar at her school. The guest speaker, a gynecologist, explained the rhythmic biological cycle that a female body undergoes starting from puberty. She described how the inner lining of a pear-shaped, bag-like organ gradually thickens and enriches with blood vessels in anticipation of receiving a developing embryo. She further explained that if the mature egg released halfway through the cycle does not encounter a sperm, this thickened lining is no longer needed and breaks down, leaving the body naturally.

127. (a) Draw a well-labelled diagram of the human female reproductive system.
- (b) Explain the journey of an egg from its release to implantation, assuming successful fertilisation takes place.

Ans :

(a)



- (b) The reproductive journey begins when an ovary releases a single mature egg during a process known as ovulation. This egg is gently swept into the adjacent oviduct, also called the fallopian tube. If sexual intercourse has occurred, actively motile sperm travel from the vagina, through the cervix and uterus, up into the fallopian tube. Here, if a single sperm successfully penetrates the egg, they fuse to form a zygote through fertilisation. Once formed, the zygote immediately begins a series of rapid mitotic cell divisions as it slowly travels down the oviduct towards the uterus. By the time this developing embryo reaches the uterus, the inner uterine lining has become thick and richly supplied with blood vessels. The embryo embeds itself deeply into this prepared lining to receive continuous nourishment and oxygen. This crucial embedding process is termed implantation, marking the start of pregnancy.

128. (a) Describe how a developing embryo transforms into a fully formed foetus across the three trimesters of human pregnancy.
- (b) Why is the physical and emotional well-being of the mother considered absolutely crucial during this gestation period?

Ans :

- (a) Pregnancy lasts roughly nine months and is divided into three distinct trimesters. During the first trimester, the basic structural

foundation is laid as the fertilised egg rapidly divides and implants; major organs start forming, and the embryo officially becomes a foetus. In the second trimester, the foetus grows significantly larger, muscles strengthen, and the mother begins to feel its active movements inside the womb. The third trimester is characterised by rapid weight gain as the baby matures completely, getting ready for life outside.

- (b) The mother's health is absolutely crucial because the developing baby relies entirely on her body for continuous nutrition, oxygen, and protection. A balanced diet and regular check-ups prevent harmful deficiencies. Equally important is her emotional well-being; high stress can negatively impact foetal development, making supportive environments essential for a safe, healthy delivery.

CASE BASED QUESTIONS

129. Farmer Ramu has a wild rose plant in his garden that has a very strong and disease-resistant root system but produces small, dull flowers. He wants to grow large, beautiful yellow roses instead. He takes a healthy stem piece from a yellow rose plant, carefully makes a slit on a twig of his wild rose plant, and inserts the yellow rose stem into the slit. He then wraps the joint securely with a cotton cloth and plastic film to protect it from pests, watering it regularly until the two parts heal and grow together.

QUESTIONS:

- (a) Which specific method of artificial vegetative propagation is Farmer Ramu using?
- (b) Why did Ramu wrap the joint with a cotton cloth and plastic film?
- (c) What is the central biological process behind this type of reproduction, and how do the new yellow roses genetically compare to the parent yellow rose plant?

Ans :

- (a) Farmer Ramu is using the method of grafting.
- (b) He wrapped the joint to avoid pests from entering the graft until it heals completely and to keep the joined area secure and protected.

CHAPTER 12

Patterns in Life: Diversity and Classification

SUMMARY

1. INDIA AS A BIODIVERSITY HOTSPOT

1. The natural landscape of India is highly diverse with mountains, deserts, rainforests, plateaus, and coastlines.
2. Each region has distinct soil types and climatic conditions like temperature and rainfall.
3. These diverse habitats support a wide variety of plant and animal species.
4. Endemic species are those restricted to particular regions of the world and not found naturally anywhere else.
5. Examples of endemic species in India include the Nilgiri tahr, Lion-tailed macaque, Indian pitcher plant *Nepenthes khasiana*, and Neelakurinji.
6. Biodiversity hotspots are regions that support a large number of endemic species but have undergone significant habitat loss.
7. These hotspots are extremely important for biodiversity conservation.
8. Global biodiversity hotspots found in India include the Western Ghats, Indo-Burma, the Himalayas, and Sundaland including the Nicobar Islands.
9. Protecting these regions ensures healthy ecosystems and stable food webs.

2. HOW HAS THE BIODIVERSITY EVOLVED?

1. The biodiversity seen on Earth today was not always the same in the past.
2. Small differences among individuals helped them adapt to changing environmental conditions.
3. These differences affected their chances of survival and their ability to reproduce.

4. Useful differences accumulated over many generations and eventually gave rise to new forms of life.
5. Biological diversity is the outcome of continuous changes occurring over a vast span of time.
6. These changes are shaped by constant interactions between living organisms and their surroundings.
7. Ancient Indian traditions like the Sangam Tinai classification helped protect sacred groves and preserve diverse habitats locally.

3. HOW TO CLASSIFY ORGANISMS?

1. Organisms in an ecosystem can be grouped in multiple ways based on different criteria.
2. A single organism can often fit into several different groups depending on the chosen criterion.
3. Scientists must decide which features to use while grouping living organisms systematically.
4. This systematic way of organising Earth's living diversity is known as classification.

3.1 Some criteria to classify living organisms

1. Scientists first look at broad and easily visible features before looking at detailed characteristics.
2. External features like shape, size, and body organisation are basic criteria for grouping.
3. Mode of nutrition is checked to see if an organism is autotrophic or heterotrophic.
4. Internal structures like skeletal patterns, presence of organs, and types of tissues are considered.
5. Cell structure is a major criterion based on whether the organism is unicellular or multicellular, prokaryote or eukaryote, and if it has a cell wall.

17. Gymnosperms are plants adapted to cold and dry regions with needle-like leaves to reduce water loss.
18. They do not require water for fertilisation.
19. They produce seeds that are not enclosed in fruits and are exposed on cones.
20. Pines and cycads are examples of Gymnosperms.
21. Angiosperms are flowering plants with the most complex body organisation.
22. They produce flowers to attract pollinators which increases reproduction efficiency.
23. Their seeds are enclosed within fruits which help spread seeds to new locations.
24. Angiosperms are the most diverse plant group and are divided into monocots and dicots based on leaf venation and seed structure.
13. They have tissue-level organisation and flattened bodies for efficient gas diffusion, with many living as parasites.
14. Nematoda or roundworms have cylindrical bodies with organ system level organisation.
15. They possess two body openings for mouth and anus, allowing efficient movement and survival in diverse environments.
16. Annelida or segmented worms show clear body segmentation and a true body cavity.
17. Segmentation offers greater flexibility and precise control of movement, with earthworms as a prime example.
18. Arthropoda possess jointed appendages and a hard external skeleton called an exoskeleton.
19. The exoskeleton provides protection, reduces water loss, and supports powerful muscles for survival in dry environments.
20. Insects, crabs, and spiders are common arthropods.
21. Mollusca show organ system level organisation with soft bodies protected by a shell.
22. Their body is segmented with a distinct head and a muscular foot, with examples including snails, squids, and octopuses.
23. Echinodermata lack a notochord but have an internal skeleton made of calcium carbonate.
24. They have spiny skin and show a shift towards internal skeletal support, with examples being starfish and sea urchins.
25. Protochordates are primitive chordates that possess a notochord at least once during their life.
26. Amphioxus is a protochordate that helps explain how animals with a notochord may have arisen from simpler forms.
27. Vertebrates are animals that possess a backbone or vertebral column.
28. They have an internal skeletal structure that supports complex vital organs like the brain and spinal cord.
29. Vertebrates show advanced sensory abilities and are classified into five broad groups.
30. These five vertebrate groups are fish, amphibians, reptiles, birds, and mammals.

6.5 Kingdom Animalia - Multicellular, heterotrophic eukaryotes

1. Animals are multicellular and heterotrophic organisms lacking cell walls.
2. They depend on other organisms for food.
3. Animals show coordinated behaviour, respond rapidly to stimuli, and actively search for food.
4. A major criterion for classifying animals is the presence or absence of a notochord.
5. A notochord is a flexible rod-shaped structure providing internal support.
6. Animals are divided into non-chordates called invertebrates and chordates based on this feature.
7. Invertebrates are animals without a notochord.
8. Porifera or pore-bearers are multicellular animals without true tissues or organs.
9. They have numerous pores allowing water flow for food and oxygen, and they remain fixed in aquatic environments like sponges.
10. Cnidaria show true tissues and specialised cells like tentacles for catching prey.
11. They possess a single opening for both food intake and waste removal, with examples being Hydra, jellyfish, and corals.
12. Platyhelminthes or flatworms show bilateral symmetry where the body can be divided into two equal halves.

7. Cyanobacteria are blue-green algae that were among the first organisms to produce oxygen through photosynthesis.
8. Ancient cyanobacteria fossils are found in structures called stromatolites in Rajasthan and Madhya Pradesh.
9. Monerans play a vital role in nutrient cycling and breaking down pollutants like sewage and pesticides.
10. Ram Bux Singh is known as the Father of Modern Biogas for his work on efficient biogas plants in India.

6.2 Kingdom Protista - Unicellular eukaryotes

1. All single-celled eukaryotes are grouped under the kingdom Protista.
2. They possess a true membrane-bound nucleus.
3. They may be without a cell wall or have a cell wall made of cellulose.
4. Most protists live in water or moist places.
5. Some protists are autotrophic while others are heterotrophic.
6. Common examples include Amoeba, Paramecium, and Euglena.
7. They act as an important link in aquatic food chains.
8. Some produce oxygen, some serve as food for small animals, and some act as decomposers in nutrient cycling.

6.3 Kingdom Fungi- Multicellular, heterotrophic eukaryotes with a cell wall

1. Fungi are mostly multicellular eukaryotic organisms.
2. They have cell walls made up of a complex sugar called chitin.
3. They are heterotrophic and cannot make their own food.
4. They absorb nutrients from dead or decaying matter through fine filaments that form a network called mycelium.
5. Most fungi are saprophytes and act as important decomposers that recycle nutrients in the soil.
6. Some fungi establish mutualistic symbiotic relationships with other organisms.
7. Other fungi live as parasites and cause diseases in plants and animals.
8. Fungi reproduce both sexually and asexually, usually by forming spores.

9. They grow best in warm and moist conditions.
10. Examples of fungi include Aspergillus, Penicillium, and mushrooms.
11. Yeast is a unique fungus because it is a unicellular organism.
12. Wild edible mushrooms have high nutritional and medicinal values and are conserved by indigenous communities.

6.4 Kingdom Plantae - Multicellular, autotrophic eukaryotes with a cell wall

1. Plants are multicellular autotrophic organisms that perform photosynthesis.
2. Their cells have a rigid cell wall primarily made up of cellulose which provides support and protection.
3. Plants form the base of most food chains and release essential oxygen.
4. Kingdom Plantae is further divided into five classes based on structural changes.
5. Thallophyta or algae are the simplest primitive plants mostly found in water.
6. Their body is a simple undifferentiated thallus that allows direct exchange of gases and nutrients.
7. Spirogyra is a common example of Thallophyta.
8. Lichens are symbiotic associations of autotrophic algae and heterotrophic fungi, and they act as natural indicators of air pollution.
9. Bryophyta represent the first steps of plants onto land but they still require water for reproduction.
10. They are called the amphibians of the plant kingdom.
11. They have a differentiated body with root-like structures called rhizoids, but lack true vascular tissues.
12. Mosses and Marchantia are examples of Bryophyta.
13. Pteridophyta are land plants that possess true roots, stems, and leaves.
14. They have specialised vascular tissues called xylem for transporting water and phloem for transporting food.
15. They require aquatic conditions for reproduction and do not produce seeds.
16. Ferns are common examples of Pteridophyta.

15. During a long-term ecological study, students examined organisms collected from three different environments - a freshwater pond, damp soil near decaying logs and the digestive tract of animals. Instead of naming organisms directly, scientists recorded only structural, cellular and nutritional features as given in the table below.

Organisms	Key Observations
P	Microscopic; no true nucleus; rigid cell covering; survives high salinity and temperature
Q	Multicellular; filamentous body; cell wall present; no chlorophyll; grows on dead organic matter
R	Unicellular; true nucleus; contractile vacuole present; moves using flagella; shows photosynthesis in light but heterotrophic in the absence of light
S	Multicellular; well-differentiated tissues; backbone present; aquatic respiration during early life stage
T	Acellular; contains genetic material; remains inactive outside a host cell

The students realised that some organisms fit neatly into Whittaker's five kingdom classification, while others challenged the very basis of this classification.

Based on the case study, answer the following questions -

- Identify one organism that clearly belongs to the Kingdom Fungi. State one observation that supports your answer.
- Which organism would be placed in the Kingdom Monera? Mention one characteristic that justifies this placement.
- Organisms R and Q are both eukaryotic, yet they are placed in different kingdoms. Analyse the criteria that separate them.
- Explain why organism S cannot be classified using the mode of nutrition alone.
- Organism T does not fit into any of the five kingdoms. Which fundamental characteristic used in classification does it lack and what does this reveal about the limitations of classification systems?
- If classification were based only on habitat, which organisms might be incorrectly grouped together? Explain the scientific consequences

of such a classification.

- Imagine scientists discover a new organism that is multicellular, eukaryotic, lacks chlorophyll and absorbs nutrients from a host externally. Should it be placed under fungi or animalia? Justify your reasoning using classification criteria.

Ans :

- Organism Q clearly belongs to the Kingdom Fungi. This is supported by the observation that it is multicellular with a cell wall, lacks chlorophyll, and grows on dead organic matter, which perfectly describes the saprophytic nature and structure of fungi.
- Organism P would be placed in the Kingdom Monera. The characteristic that justifies this placement is that it lacks a true nucleus, meaning it is a prokaryote, which is the defining feature of all organisms in the Monera kingdom.
- The primary criterion separating them is their level of cellular organisation and mode of nutrition. Organism R is unicellular, placing it in the Kingdom Protista, and has the ability to photosynthesise. In contrast, Organism Q is multicellular with a filamentous body and is strictly heterotrophic (saprophytic), placing it in the Kingdom Fungi.
- Organism S cannot be classified using the mode of nutrition alone because being a heterotrophic consumer is a broad trait shared by both animals and fungi, as well as some protists and bacteria. To accurately classify organism S as a vertebrate animal, scientists must rely on its advanced structural features, such as the presence of well-differentiated tissues and a backbone.
- Organism T (a virus) lacks a cellular structure altogether (it is acellular), meaning it does not have the basic prokaryotic or eukaryotic framework required for the five kingdom system. This reveals that our biological classification systems are limited because they are constructed around the typical rules of self-sustaining cellular life, making it difficult to categorise boundary entities that exist between the living and non-living worlds.
- If classification were based solely on habitat, vastly different organisms like a simple protist (Organism R) and a complex vertebrate (Organism S) might be incorrectly grouped together simply because both can be found in a

7. ADAPTATIONS AS OUTCOMES OF STRUCTURAL CHANGE

1. The diversity seen in animals today consists of outcomes of changes in body structure over long periods of time.
2. Fins and gills are structural changes that allow fish to move and breathe in water.
3. Feathers and hollow bones are adaptations that make flight possible in birds.
4. Fat storage in camels and thick fur in polar bears are structural features that support survival under extreme conditions.
5. Mammary glands represent a structural and functional change in mammals that improves the survival of young ones.
6. All these animal characteristics reflect a wide range of body forms adapted for living under different environmental challenges.

7.1 The hierarchical nature of classification

1. Classification follows a step-by-step hierarchical order starting from very broad groups to smaller and specific ones.
2. The levels from top to bottom are Kingdom, Phylum, Class, Order, Family, Genus, and Species.
3. At each lower level, the grouped organisms share more common features.
4. This step-by-step arrangement works like an address to help scientists locate a place exactly.
5. It helps scientists identify, compare, and study organisms accurately to understand how they are related.

8. SCIENTIFIC NAMING - THE BINOMIAL SYSTEM

1. Common names for animals create confusion because people from different regions use different languages.
2. Carolus Linnaeus introduced a universal system of naming living organisms called binomial nomenclature in the 18th century.
3. Every organism has a scientific name with two parts written in Latin or a Latinised form.
4. The first part is the name of the genus and the second part is the name of the species.
5. Species name indicates a group of similar individuals capable of interbreeding and producing offspring.

NODIA

6. The genus name begins with a capital letter and the species name is written entirely in small case letters.
7. The scientific name is written in italics when printed or underlined separately when handwritten.
8. Examples include *Panthera tigris* for tiger and *Mangifera indica* for mango.
9. Carl Woese in 1977 proposed the three domain system which groups life into Bacteria, Archaea, and Eukarya.
10. This three domain system is based on similarities in genetic data and DNA, showing microscopic life is far more diverse than previously believed.

9. FOSSILS AS EVIDENCE

1. Fossils are the preserved remains of plants and animals found in layers of rocks, sand, and mud.
2. Fossils act as natural records providing evidence of how diversity has changed over millions of years.
3. Older and deeper rock layers generally contain simpler organisms.
4. Newer top layers show more complex living forms.
5. Birbal Sahni was an eminent Indian scientist who founded an institute in Lucknow to study fossil plants.
6. His studies of fossils helped link present-day plants with their ancient ancestors.

10. BIODIVERSITY UNDER THREAT

1. Each species plays an important ecological role such as producing oxygen, pollinating flowers, or recycling nutrients.
2. Human activities like pollution, deforestation, overuse of resources, and climate change are severely reducing biodiversity.
3. When one species disappears, other dependent species also decline in number and eventually disappear.
4. The Purple Frog, *Nasikabatrachus sahyadrensis*, discovered in 2003, highlights the need for conservation in the Western Ghats.
5. Floating grasslands called phumdis in Manipur are unique habitats located in the Loktak lake.

6. These phumdis support an endangered dancing deer called Sangai which has unique hooves adapted for this environment.
7. Habitat loss and degeneration of phumdis are threatening the Sangai deer population, leading to active conservation efforts.

PAUSE AND PONDER

1. If many organisms share common features, could they also share a common ancestry?

Ans :

Yes, if many organisms share common fundamental features, it strongly suggests that they share a common ancestry. Similar characteristics in different organisms indicate that they have inherited these traits from a shared evolutionary ancestor before diverging into distinct species over time.

2. How can a single-celled organism carry out all its life processes when billions of cells are required to perform similar functions in multicellular organisms like us?

Ans :

A single-celled organism can carry out all essential life processes because its single cell is highly complex and contains specialised subcellular structures called organelles. Each organelle functions like a miniature organ, performing specific tasks such as digestion, respiration, and excretion. Unlike multicellular organisms where cells specialise and form tissues to divide labour, a unicellular organism manages this division of labour at the organelle level within a single cell.

3. Which plant features reduce their dependence on water but still require moist conditions?

Ans :

Bryophytes show features like a slightly differentiated plant body with root-like structures (rhizoids) and leaf-like structures that allow them to live on land, reducing their absolute dependence on an aquatic habitat. However, they lack true vascular tissues for transport and require water for reproduction because their male reproductive cells must swim to reach the female cells, which is why they still require moist conditions to survive.

4. Why do taller plants need specialised transport tissues?

Ans :

Taller plants need specialised transport tissues, namely xylem and phloem, to effectively move essential resources over long distances against gravity. Xylem is necessary to transport water and dissolved minerals absorbed by the roots up to the leaves for photosynthesis. Phloem is required to distribute the food prepared in the leaves to all other parts of the sprawling plant body, ensuring its survival and growth.

5. How do seeds and fruits affect, where and how plants can survive?

Ans :

Seeds enclose the developing embryo within a protective coat and provide stored food, allowing plants to survive harsh conditions and reproduce without relying on external water. Fruits aid in the widespread dispersal of these seeds through various agents like wind, water, or animals. These evolutionary features allow plants like angiosperms to colonise a much wider, drier range of environments and ensure the continuity of their species across diverse habitats. An earthworm (annelida) and a beetle (arthropoda), both have segmented bodies but the beetle has a hard external skeleton.

6. How does the beetle's external skeleton help it survive?

Ans :

The beetle's hard external skeleton, or exoskeleton, provides crucial protection against physical injury and predators. It also significantly reduces water loss from the body, enabling the beetle to survive in dry, terrestrial habitats. Additionally, the rigid exoskeleton provides sturdy attachment points for powerful muscles, facilitating better leverage and complex jointed movements in exposed environments.

7. Does the term 'biodiversity' relate only to the variety of organisms, or does it encompass other elements?

Ans :

The term 'biodiversity' primarily relates to the immense variety of living organisms, from microbes to giant trees, and the myriad of species

on Earth. However, it also inherently encompasses the diverse habitats and complex ecosystems they inhabit, such as forests, coral reefs, and deserts. Furthermore, it includes the intricate interconnections, food webs, and ecological roles that sustain these environments and make Earth suitable for life.

8. If you find a new organism in a pond, what features will you observe to classify it and why?

Ans :

To systematically classify a newly found pond organism, I would first observe its cellular structure under a microscope to determine if it is a prokaryote (no defined nucleus) or a eukaryote, and whether it is unicellular or multicellular. Next, I would look for the presence or absence of a cell wall and observe its mode of nutrition to see if it is autotrophic (photosynthetic) or heterotrophic. These fundamental characteristics form the basis of the five-kingdom classification system, allowing me to accurately place the organism into groups like Monera, Protista, Fungi, Plantae, or Animalia.

9. Why do genetic studies provide deep information about living beings?

Ans :

Genetic studies provide deep information because they analyse the DNA, which carries the fundamental instructions for an organism's growth, development, and function. By comparing genetic material at a molecular level, scientists can identify shared inherited features and determine true evolutionary relationships, even when external appearances might be misleading. This detailed analysis helps accurately trace common ancestry and has allowed scientists to refine biological classification into systems like the three domains of life.

10. How can changes in climate affect the biodiversity?

Ans :

Changes in climate can rapidly alter the specific environmental conditions, such as temperature and moisture, to which native species are finely adapted. This can lead to habitat loss or degradation, making it difficult for organisms to find food, survive extreme conditions, or reproduce successfully. Consequently, these changes stress interconnected ecosystems, causing a decline in vulnerable populations and eventually leading to

the disappearance of multiple species, thereby reducing overall biodiversity.

NCERT EXERCISE

1. Meena and Hari observed an animal in their garden. Hari called it an insect while Meena said it was an earthworm. Choose the correct option which confirms that it is an insect.
- Bilateral symmetrical body
 - Body with jointed legs
 - Cylindrical body
 - Body with little segmentation

Ans :

Option (ii) Body with jointed legs. Insects belong to the phylum Arthropoda, and the defining structural feature of arthropods is the presence of jointed appendages (legs), distinguishing them from earthworms which belong to Annelida.

2. Sponges represent one of the simplest animal body plans. Their bodies lack true tissues and organs. Which feature of sponge cells supports its classification under the animal kingdom?
- Absence of mitochondria
 - Ability to photosynthesise
 - Presence of a cell membrane
 - Presence of a cell wall

Ans :

Option (iii) Presence of a cell membrane. Animal cells are eukaryotic and, unlike plants and fungi, they lack a rigid cell wall, meaning their outer boundary is solely the cell membrane.

Observe two different animals in your immediate environment. What features help you distinguish between them? How do these features help place them into different groups?

Ans :

If we observe a bird (like a pigeon) and an earthworm in our environment, we can distinguish them by several visible structural features. The bird possesses feathers, wings, an internal skeleton with a backbone, and well-developed sensory organs, whereas the earthworm has a cylindrical, segmented body with no internal skeleton or limbs. These distinct features help classify them accurately: the earthworm is placed under Invertebrates (Phylum Annelida) due to

its segmentation and lack of a notochord, while the bird is placed under Vertebrates (Class Aves) because it has a vertebral column and structural adaptations for flight.

4. How would a scientist justify choosing cellular organisation as a more fundamental characteristic for the basis of classification rather than the presence of xylem and phloem?

Ans :

A scientist would justify this by explaining that cellular organisation (such as being prokaryotic or eukaryotic, unicellular or multicellular) is a universal trait that applies to all living things on Earth, allowing for the creation of broad primary groupings like the five kingdoms. In contrast, the presence of xylem and phloem is a highly specific structural adaptation found only in a subset of the plant kingdom (vascular plants). Classification must follow a hierarchical step-by-step order, starting from the broadest, most inclusive features before moving to smaller, highly specific traits.

5. You find an unlabelled slide of a single-celled organism that has a well-defined nucleus and multiple cilia. Which group would it most likely belong to? Give reasons.

Ans :

The organism would most likely belong to the kingdom Protista. The presence of a well-defined nucleus indicates that the organism is a eukaryote, and being single-celled is the defining criteria for the Protista kingdom. Furthermore, the presence of cilia suggests it is a motile organism similar to Paramecium, which is a classic example of a protist.

6. How does the diversity of organisms contribute to the balance and stability of an ecosystem?

Ans :

The diversity of organisms ensures ecosystem balance through complex interconnections where every living being plays a crucial ecological role. For example, microscopic algae and plants act as producers by capturing sunlight and releasing oxygen, forming the base of food chains. Animals act as consumers that regulate populations, while fungi and bacteria act as decomposers by breaking down dead matter and recycling essential nutrients back into the soil. This immense variety

sustains food webs, maintains soil fertility, and makes the ecosystem resilient enough to support all life on the planet.

7. If all unicellular organisms were grouped into a single kingdom, what problems would arise?

Ans :

Grouping all unicellular organisms into a single kingdom would create major scientific confusion because it would mix organisms with fundamentally different cellular architectures. It would force prokaryotes (like bacteria, which have a primitive nucleus without a membrane) into the same category as eukaryotes (like amoeba and yeast, which possess a true membrane-bound nucleus and complex organelles). Because the cellular structure is the most basic evolutionary divergence in life, ignoring it would result in a classification system that fails to show true evolutionary relationships.

8. Viruses were studied in earlier classes. Why are they not placed in any of the five kingdoms? Give reasons.

Ans :

Viruses are not placed in the five kingdom classification because they completely lack cellular organisation, which is the foundational criteria for Whittaker's system. They are acellular entities that do not have a cell membrane, cytoplasm, or cellular organelles, and they remain entirely inactive outside of a host cell. Since the five kingdoms (Monera, Protista, Fungi, Plantae, Animalia) are designed strictly to categorise living, cellular organisms, viruses cannot be accommodated within them.

9. If you were asked to revise the five kingdom classification, would you create a separate category for viruses or keep them outside the system? Justify your answer and explain what this indicates about the evolving nature of scientific classification.

Ans :

I would create a separate, distinct category (such as an "Acellular" domain) for viruses rather than leaving them entirely outside the classification system. While they lack the cellular structure required for the five kingdoms, they possess genetic material, interact dynamically with living hosts, and play significant roles in ecology and

disease, making it necessary to study and classify them systematically. This indicates that scientific classification is not a rigid, permanent set of rules; rather, it is an ongoing process of reasoning and change that evolves as technological advancements and new discoveries challenge existing frameworks.

10. Viruses contain genetic material like living organisms but lack cellular organisation. Which features prevent them from fitting into the five kingdom system? What does this tell us about the limitations of classification systems?

Ans :

The primary feature preventing viruses from fitting into the five kingdom system is their lack of a cell type (they are neither prokaryotic nor eukaryotic) and their inability to perform life processes, like metabolism or reproduction, independently outside a host. This tells us that human-made classification systems have inherent limitations because they are built based on the broad patterns of typical, known life forms at a specific point in time. When entities like viruses blur the strict boundaries between living and non-living, they expose the difficulty of fitting the immense and complex diversity of nature into neat, definitive boxes.

11. Both pteridophytes and bryophytes lack flowers and seeds, yet they are placed in different groups. Explain this classification using their key features.

Ans :

Although both groups share the absence of flowers and seeds and require water for reproduction, they are placed in different groups based on their level of body differentiation and internal transport systems. Bryophytes represent a simpler body plan that lacks true roots, stems, or leaves (possessing only root-like rhizoids) and completely lacks vascular tissues. In contrast, Pteridophytes show a significant structural advancement by possessing true roots, stems, and leaves, along with specialised vascular tissues (xylem and phloem) that efficiently transport water and food throughout the plant.

12. In the classification hierarchy, which group - class or genus - has fewer members but more features in common? Explain your answer.

Ans :

The genus has fewer members but more features in common compared to a class. Biological classification follows a step-by-step hierarchical order where groups at the top (like class) are very broad and contain a large number of diverse organisms that share only a few fundamental traits. Because a genus is located much lower down the hierarchy, just above the species level, it represents a highly specific address containing a smaller number of closely related organisms that share a vast amount of detailed genetic and structural similarities.

A scientist discovers a new organism with the characteristic features of locomotion and autotrophic nutrition. Which character(s) would help the scientist identify the organism belonging to Protista according to the five kingdom classification?

Ans :

To classify this newly discovered organism under the kingdom Protista, the scientist must confirm the fundamental cellular characteristics: the organism must be strictly unicellular and eukaryotic (possessing a membrane-bound true nucleus). While features like locomotion (using structures like flagella) and autotrophic nutrition (photosynthesis) are observable traits that occur in certain protists like Euglena, it is the combination of being a single-celled eukaryote that serves as the definitive placement criteria for Kingdom Protista.

14. A researcher identified a unicellular eukaryotic organism as fungi. What identification key would you suggest according to the five kingdom classification to keep a unicellular organism in the Kingdom Fungi?

Ans :

To justify keeping a unicellular eukaryotic organism (such as yeast) in the Kingdom Fungi instead of Protista, the primary identification keys would be its cell wall composition and its mode of nutrition. The researcher must confirm that the organism possesses a rigid cell wall made of chitin and exhibits a heterotrophic (specifically saprophytic) mode of nutrition where it absorbs nutrients from dead or decaying organic matter.

6. The ecological role of an organism as a producer, consumer, or decomposer is also used for grouping.
7. Reproduction methods are checked to see if they use asexual or sexual methods.
8. Genetic similarity is studied in detail using DNA to find inherited features.
9. Similar features in different organisms suggest that they have evolved from common ancestors.

4. THE NEED FOR CLASSIFICATION

1. Finding information about millions of organisms without systematic arrangement would be very difficult.
2. Classifying organisms systematically is like arranging books in a library by subject or author.
3. Biological classification helps make the study of vast diversity easier, more organised, and systematic.
4. It helps us understand the similarities and differences among various living beings.
5. It shows how different organisms are related to one another and how they interact in nature.
6. It helps in easily identifying and naming newly discovered organisms.
7. It supports biodiversity conservation by identifying specific organisms that are under the threat of extinction.
8. It allows scientists all over the world to discuss organisms using one common system.

5. BIOLOGICAL CLASSIFICATION SYSTEMS OVER TIME

1. Classification systems have developed over time based on the available scientific knowledge.
2. Aristotle in the fourth century BCE grouped animals based on their habitat as land, water, and air.
3. Aristotle also grouped them based on their external appearances, but this system had many limitations.
4. Carolus Linnaeus in 1758 introduced the Two Kingdom system dividing all life into Plantae and Animalia.

5. This two kingdom system caused confusion about where to place organisms like Amoeba, Paramecium, and bacteria.
6. Ernst Haeckel in 1866 added a third kingdom called Protista to include unicellular microscopic organisms.
7. Herbert F Copeland in 1938 created a Four Kingdom system by adding the kingdom Monera for bacteria which lack a true nucleus.
8. Robert H Whittaker in 1969 proposed the Five Kingdom classification system.
9. Whittaker separated fungi into their own kingdom because they have a heterotrophic mode of nutrition and absorb nutrients.
10. The five kingdoms are Monera, Protista, Fungi, Plantae, and Animalia.

6. FIVE KINGDOM CLASSIFICATION

1. In the five kingdom classification, all life forms are grouped based on certain common criteria.
2. The main criteria are cell type, level of organisation, cell structure, and mode of nutrition.
3. Cell type checks for a primitive unbound nucleus in prokaryotes or a membrane-bound nucleus in eukaryotes.
4. Level of organisation checks if the organism is unicellular or multicellular.
5. Cell structure checks for the presence or absence of a cell wall, and whether it is made of chitin or cellulose.
6. Mode of nutrition checks if organisms are autotrophic producers or heterotrophic consumers and decomposers.

6.1 Kingdom Monera - Unicellular prokaryotes

1. Members of Kingdom Monera are single-celled prokaryotes.
2. They lack a true bound nucleus and their genetic material is not enclosed in a membrane.
3. Bacteria and cyanobacteria belong to this kingdom.
4. They are found in soil, water, air, hot springs, extreme environments, and inside human bodies.
5. Some bacteria are harmful pathogens that cause diseases.
6. Many bacteria are useful, such as Lactobacillus and Rhizobium.

freshwater aquatic environment. The scientific consequence of this artificial classification is that it creates immense confusion and fails to reflect true evolutionary relationships, as it completely ignores the massive internal biological and cellular differences between the organisms.

- (vii) This new organism should primarily be placed under Kingdom Fungi based on its mode of nutrition. While both animals and fungi are multicellular, eukaryotic, and lack chlorophyll, animals typically exhibit an ingestive mode of nutrition with internal digestion. Fungi, however, are distinct in that they exhibit an absorptive mode of nutrition, secreting enzymes and absorbing nutrients externally from their surroundings or a host, which aligns perfectly with the description of the new organism.

OBJECTIVE QUESTIONS

- Which of the following best defines endemic species?
 - Species found evenly distributed across all continents.
 - Species strictly restricted to particular geographical regions of the world.
 - Species that have gone extinct globally.
 - Microscopic species that migrate between different countries seasonally.

Ans : (B)

Endemic species are those that are strictly restricted to particular geographical regions of the world and are not found naturally anywhere else. Examples from India include the Nilgiri tahr, Lion-tailed macaque, and the Indian variety of the pitcher plant. Protecting these unique species is crucial for maintaining global biodiversity.

- Identify the species that is NOT correctly matched with its status as an endemic species found only in India based on given examples.
 - Nilgiri tahr
 - Lion-tailed macaque
 - Polar bear
 - Neelakurinji

Ans : (C)

The Nilgiri tahr, Lion-tailed macaque, and Neelakurinji are well-known examples of endemic

species restricted to the diverse natural landscapes of India. In contrast, the polar bear is native to the Arctic region, adapting to extreme cold, and does not naturally occur anywhere within the diverse climatic zones of the Indian subcontinent.

- Assertion (A):** Regions like the Western Ghats and the Himalayas are considered global biodiversity hotspots.

Reason (R): These regions support a remarkably large number of endemic species and have simultaneously undergone significant habitat loss over time.

- Both A and R are true and R is the correct explanation of A
- Both A and R are true but R is not the correct explanation of A
- A is true but R is false
- A is false but R is true

Ans : (A)

Biodiversity hotspots are specific regions crucial for global conservation efforts. To qualify as a hotspot, an area must harbor an exceptionally high number of endemic species found nowhere else. Furthermore, these regions must have experienced substantial habitat destruction, making their protection absolutely critical to preserve the remaining biodiversity and ecological balance.

- Who is popularly known as the 'Father of Modern Biogas' for establishing India's first scientifically designed biogas plant?
 - Carolus Linnaeus
 - Ram Bux Singh
 - Robert H. Whittaker
 - Birbal Sahni

Ans : (B)

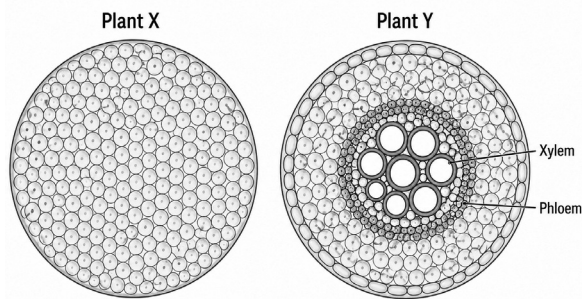
Ram Bux Singh is widely recognized as the 'Father of Modern Biogas'. He pioneered systematic modern biogas research in India by establishing the first scientifically designed biogas plant at Ramnagar, Uttar Pradesh. His lifelong dedication significantly contributed to promoting renewable energy, effective waste management, and sustainable development technologies, especially in rural areas.

The incredible diversity of life seen on Earth today is primarily an outcome of which of the following processes?

- Sudden appearance of all species simultaneously in one century.

is the defining hallmark separating them from prokaryotic monerans and multicellular eukaryotes.

14. The cross-sections belong to two different plant groups found in moist habitats. Which of the following correctly identifies the evolutionary advantage present in Plant Y that allows it to survive on land better than Plant X?



- (A) Plant Y relies on surrounding water for structural support.
- (B) Plant Y can produce seeds for reproduction without water.
- (C) Plant Y has specialized tissues for conducting water and food.
- (D) Plant Y possesses a simple thallus body for direct absorption.

Ans : (C)

Plant Y displays distinct xylem and phloem, identifying it as a pteridophyte or higher plant with a developed vascular system. This specialized tissue allows efficient transport of water and nutrients, unlike the uniform, non-vascular structure of Plant X (bryophyte). Options B is incorrect as ferns lack seeds. Options A and D describe simpler non-vascular plants.

15. Observe the given analogy carefully and select the missing term.

Monera : Prokaryotic :: Fungi : ?

- (A) Autotrophic and Unicellular
- (B) Multicellular (predominantly) and Heterotrophic
- (C) Unicellular without cell wall
- (D) Prokaryotic and Symbiotic

Ans : (B)

The relationship highlights the defining characteristics of specific biological kingdoms. Kingdom Monera exclusively consists of simple, single-celled prokaryotic organisms. By following

this established logical pattern, organisms belonging to Kingdom Fungi are predominantly characterized as complex, multicellular, and strictly heterotrophic eukaryotes, distinguishing their unique biological and ecological roles from other distinct classification groups within the system.

16. Read the following statement :

- 1. They are mostly multicellular eukaryotes.
- 2. Their cell walls are primarily made of cellulose.
- 3. They are exclusively autotrophic in nature.
- 4. Many are saprophytes, absorbing nutrients from dead matter.

Which of the above statements correctly describe the essential characteristics of Kingdom Fungi?

- (A) 1 and 4 only
- (B) 1, 2, and 4
- (C) 2 and 3 only
- (D) 1, 3, and 4

Ans : (A)

Members of Kingdom Fungi are predominantly multicellular, highly complex eukaryotic organisms. Unlike plants, their distinct cell walls are primarily composed of chitin, not cellulose. Furthermore, they entirely lack chlorophyll and are strictly heterotrophic. They primarily function ecologically as vital saprophytes, actively absorbing essential nutrients by meticulously decomposing complex dead or decaying organic matter present in their environment.

17. Identify the odd one out based entirely on the evolutionary sequence and the strict dependence on environmental water for sexual reproduction in the plant kingdom.

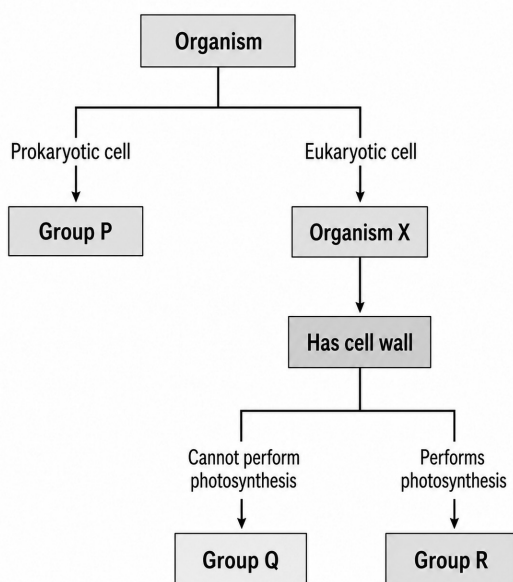
- (A) Thallophyta
- (B) Bryophyta
- (C) Pteridophyta
- (D) Gymnosperm

Ans : (D)

Thallophyta, Bryophyta, and Pteridophyta are all relatively primitive plant groups that absolutely require aquatic conditions or substantial moisture for their reproductive processes, as their male gametes must swim. In stark contrast, Gymnosperms represent a significant evolutionary advancement; they are highly adapted to dry terrestrial environments and definitely do not rely on water for successful fertilization.

body organization, noting unicellularity versus multicellularity; and the primary mode of nutrition. The presence or absence of blood is entirely irrelevant for classifying organisms at the kingdom level.

10. Based on the given classification flowchart, which biological kingdoms do Group P and Group Q represent respectively?



- (A) Monera and Fungi
 (B) Protista and Animalia
 (C) Monera and Plantae
 (D) Protista and Fungi

Ans : (A)

Group P organisms are prokaryotic, correctly identifying them as Kingdom Monera, since they lack a membrane-bound nucleus. Group Q organisms are eukaryotic, possess a cell wall, but are strictly heterotrophic (cannot perform photosynthesis). This combination uniquely defines Kingdom Fungi. Protista includes eukaryotes, while Plantae consists of autotrophic organisms, eliminating other options.

11. **Assertion (A):** Bacteria and cyanobacteria are grouped together under the Kingdom Monera.

Reason (R): Both bacteria and cyanobacteria are single-celled eukaryotic organisms lacking a true nucleus.

- (A) Both A and R are true and R is the correct explanation of A

- (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

Bacteria and cyanobacteria are indeed accurately classified together within the Kingdom Monera. However, the reasoning provided is factually incorrect because these organisms are actually single-celled prokaryotes, not eukaryotes. Prokaryotic cells are uniquely characterized by the distinct absence of a true, membrane-bound nucleus, distinguishing them fundamentally from all other life forms grouped in subsequent eukaryotic kingdoms.

12. Which specific group of microscopic organisms is believed to have played a crucial evolutionary role in making early Earth suitable for other life forms by releasing oxygen?

- (A) Fungi
 (B) Cyanobacteria
 (C) Sponges
 (D) Lichens

Ans : (B)

Cyanobacteria, also known as blue-green algae, hold immense evolutionary significance. They are considered among the very first organisms to possess the ability to produce oxygen through the vital process of photosynthesis. Over billions of years, this steadily accumulated oxygen drastically altered the Earth's early atmosphere, ultimately creating an environment capable of sustaining diverse, complex life forms.

13. An organism observed under a microscope is strictly single-celled, has a distinct membrane-bound nucleus, and possesses a delicate cell wall. To which kingdom does it most likely belong?

- (A) Monera
 (B) Protista
 (C) Fungi
 (D) Animalia

Ans : (B)

The kingdom Protista encompasses a diverse array of single-celled organisms that are distinctly eukaryotic, meaning they possess a true, membrane-bound nucleus. While some protists entirely lack cell walls, others may have cell walls primarily composed of cellulose. This specific combination of being unicellular and eukaryotic

- (B) Continuous changes occurring over a vast span of time shaped by environmental interactions.
- (C) Artificial breeding by early humans in a laboratory setting.
- (D) Extraterrestrial introduction of different animal forms directly onto land habitats.

Ans : (B)

The remarkable biological diversity present on Earth is the direct result of continuous, gradual changes occurring over massive spans of time. Small variations among individuals helped them adapt better to shifting environmental conditions. These beneficial differences accumulated over countless generations, eventually giving rise to entirely new forms of living organisms.

6. 1. Whether the cell is prokaryotic or eukaryotic.
 2. Whether the organism is exclusively terrestrial or aquatic.
 3. Whether the organism is unicellular or multicellular.

Which of the above statements represent fundamental criteria used by scientists to broadly classify living organisms?

- (A) 1 and 2 only
- (B) 2 and 3 only
- (C) 1 and 3 only
- (D) 1, 2, and 3

Ans : (C)

Scientists utilize fundamental cellular characteristics to classify organisms broadly. Key criteria include the basic cell structure, specifically determining whether it is prokaryotic or eukaryotic, and the level of body organization, identifying if it is unicellular or multicellular. Habitat, whether terrestrial or aquatic, is generally not a primary cellular criterion for broad classification.

7. 1. Two Kingdom System
 2. Five Kingdom System
 3. Aristotle's System
 4. Three Kingdom System

Arrange the above classification systems in the correct chronological order of their historical introduction.

- (A) 3, 1, 4, 2
- (B) 1, 3, 4, 2
- (C) 3, 4, 1, 2
- (D) 1, 2, 3, 4

Ans : (A)

The earliest known biological classification was proposed by Aristotle around the fourth century BCE. Much later, Carolus Linnaeus introduced the Two Kingdom system in 1758. This was followed by Ernst Haeckel's Three Kingdom system in 1866. Finally, Robert H. Whittaker proposed the widely accepted Five Kingdom classification system in the year 1969.

8. Match List-I with List-II and select the correct

	List-I (Scientist)		List-II (System Proposed)
P.	Carolus Linnaeus	1.	Five Kingdom System
Q.	Ernst Haeckel	2.	Four Kingdom System
R.	Herbert F. Copeland	3.	Three Kingdom System
S.	Robert H. Whittaker	4.	Two Kingdom System

- (A) P-4, Q-2, R-3, S-1
- (B) P-4, Q-3, R-2, S-1
- (C) P-3, Q-4, R-1, S-2
- (D) P-1, Q-2, R-3, S-4

Ans : (B)

The history of taxonomy features several key scientists. Carolus Linnaeus introduced the foundational Two Kingdom classification in 1758. Later, Ernst Haeckel expanded this to a Three Kingdom system in 1866. Herbert F. Copeland further refined it into a Four Kingdom model in 1938. Ultimately, Robert H. Whittaker established the comprehensive Five Kingdom classification in 1969.

Which of the following is NOT one of the primary criteria forming the basis of Whittaker's five kingdom classification?

- (A) Cell type (prokaryote or eukaryote)
- (B) Presence or absence of blood
- (C) Level of organisation (unicellular or multicellular)
- (D) Mode of nutrition (autotrophic or heterotrophic)

Ans : (B)

Robert H. Whittaker's widely accepted five-kingdom classification system is strictly based on fundamental biological criteria. These include cellular structure, specifically distinguishing between prokaryotic and eukaryotic cells;

18. Lichens remarkably represent a highly symbiotic, mutualistic relationship between an autotrophic alga and a heterotrophic fungus. In nature, what crucial environmental indicator role do lichens actively play?

(A) Indicators of deep underground water
 (B) Natural bioindicators of air pollution levels
 (C) Indicators of rich mineral deposits in soil
 (D) Indicators of incoming seasonal rainfall

Ans : (B)

Lichens are fascinating composite organisms formed by a mutually beneficial symbiotic relationship between a fungus and an alga. They are highly sensitive to their immediate environment. Specifically, they act as remarkable natural bioindicators. By visibly changing their distinct color, researchers can accurately determine the specific concentration of harmful pollutants present in the surrounding air, helping measure overall air quality.

19. A student observes four different microscopic organisms collected from a local pond and records their cellular characteristics in a table. Based on the recorded data, which organism plays the primary ecological role of a decomposer by breaking down complex organic matter into simpler substances?

Organism	Nuclear Membrane	Cell Wall Composition	Mode of Nutrition
A	Absent	Present	Autotrophic
B	Present	Cellulose	Autotrophic
C	Present	Chitin	Heterotrophic
D	Present	Absent	Heterotrophic

(A) Organism A
 (B) Organism B
 (C) Organism C
 (D) Organism D

Ans : (C)

Organism C possesses a membrane-bound true nucleus, a specialized cell wall composed of chitin, and relies on heterotrophic nutrition. These specific traits distinctly identify it as a member of Kingdom Fungi. Fungi function as crucial decomposers in ecosystems by absorbing essential nutrients from dead organic matter and recycling minerals.

20. **Assertion (A):** Bryophytes are widely and accurately referred to as the 'amphibians' of the plant kingdom.

Reason (R): They are perfectly adapted to live their entire life cycle in extremely dry, arid desert environments.

(A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

Bryophytes are fittingly called the 'amphibians' of the entire plant kingdom because, although they were among the first plants to successfully colonize land, they still absolutely require substantial moisture for survival and, most importantly, for successful reproduction. They cannot survive in completely dry, arid environments, as their male gametes must swim through water to reach the female cells.

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21. Arrange the given plant groups in the correct evolutionary sequence of increasing structural complexity and successful adaptation to terrestrial life.

1. Angiosperms
 2. Thallophyta
 3. Pteridophyta
 4. Bryophyta
 5. Gymnosperms
 (A) 2, 4, 3, 5, 1
 (B) 2, 3, 4, 1, 5
 (C) 4, 2, 3, 5, 1
 (D) 2, 4, 5, 3, 1

Ans : (A)

The evolutionary sequence reflecting increasing structural complexity begins with simple, aquatic Thallophyta. Next are Bryophyta, the first land colonizers lacking true roots. Pteridophyta follow, developing essential vascular tissues. Gymnosperms evolved further by producing vital naked seeds for survival. Finally, Angiosperms represent the most highly complex plants, characterized by developing functional flowers and protective fruits for efficient reproduction.

- (C) Platyhelminthes
(D) Nematoda

Ans : (D)

Roundworms, belonging to the phylum Nematoda, exhibit a remarkably efficient elongated and cylindrical body design. Crucially, they introduce a significantly advanced organ system level of organization. This specific design includes a complete digestive tract featuring two entirely separate external openings: a distinct mouth for continuous food intake and a separate anus for the highly efficient, continual elimination of bodily waste.

31. A botanist categorizes four different plant groups based on their evolutionary adaptations for terrestrial survival. Identify which plant code correctly represents a fern (Pteridophyta), and determine its primary evolutionary advantage over plant code P-2.

Plant Code	Distinct Root, Stem, and Leaf	Vascular Tissue	Produces Seeds	Seeds Enclosed in Fruit
P-1	Absent	Absent	Absent	Absent
P-2	Present	Absent	Absent	Absent
P-3	Present	Present	Absent	Absent
P-4	Present	Present	Present	Absent

- (A) P-1; it features a simple thallus body that allows direct absorption of water and nutrients from the surroundings.
(B) P-2; it acts as a plant amphibian capable of surviving on moist land without requiring a transport system.
(C) P-3; it possesses specialized vascular tissues that transport water and food efficiently throughout the plant body.
(D) P-4; it adapts to harsh dry environments by producing exposed seeds on cones to ensure reproductive success.

Ans : (C)

P-3 represents pteridophytes, like ferns, which exhibit a differentiated plant body and specialized vascular tissues (xylem and phloem) but do not produce seeds. This vascular system is a significant evolutionary advancement over bryophytes (P-2), permitting P-3 plants to transport water and food efficiently across much larger physical plant structures.

32. **Assertion (A):** Arthropods are arguably one of the most highly successful biological groups capable of surviving in diverse, extremely exposed terrestrial environments.

Reason (R): They exclusively possess a tough, hard external skeleton which provides crucial physical protection and significantly reduces dangerous water loss.

- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Arthropods represent an incredibly successful and diverse animal phylum, thriving in numerous harsh terrestrial habitats. Their remarkable survival ability is primarily due to a defining structural feature: a rigid, tough external skeleton. This crucial outer covering provides excellent physical protection against predators, supports powerful internal muscles, and critically prevents excessive, fatal water evaporation in extremely dry and highly exposed environments.

33. Animals featuring a distinct head, a strong muscular foot, a prominent visceral hump, and often physically protected by a secreted hard shell of calcium carbonate strictly belong to which phylum?

- (A) Annelida
(B) Arthropoda
(C) Mollusca
(D) Echinodermata

Ans : (C)

Organisms classified within the phylum Mollusca, including familiar animals like snails and octopuses, typically possess soft, unsegmented bodies. Their fundamental anatomical plan generally features a distinct, well-defined head region, a strong muscular foot used for locomotion, and a visceral hump. Furthermore, many vulnerable molluscs develop a tough, protective outer shell primarily composed of rigid calcium carbonate for essential defense.

34. Which of the following pairs correctly accurately matches the specific animal phylum with its primary defining structural characteristic?

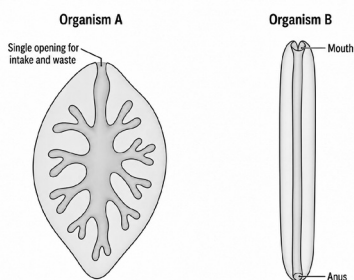
- (A) Annelida – Presence of heavily jointed external appendages

- (C) Definite organ level organisation
(D) Highly advanced organ system level

Ans : (A)

Sponges, properly classified under the phylum Porifera, represent one of the simplest structural body plans within the entire animal kingdom. Although they are definitively multicellular organisms, their fundamental body organization strictly remains at the basic cellular level. Their individual cells never structurally organize together to form distinct, specialized true tissues or more complex, highly functional internal organs.

27. What major evolutionary advancement in body design is demonstrated by Organism B compared to Organism A?



- (A) Development of a rigid external skeleton for protection.
(B) Presence of a complete digestive tract with two separate openings.
(C) Transition from multicellularity to tissue-level organization.
(D) Development of a notochord for internal structural support.

Ans : (B)

Organism B depicts an organ system-level body plan (like Nematoda) featuring a complete digestive tract with separate mouth and anus. This allows more efficient processing of food compared to Organism A (like Platyhelminthes), which has a single opening for both intake and waste. Exoskeletons and notochords are not depicted in these internal digestive schematics.

28. Organisms like Hydra (phylum Cnidaria) uniquely possess specialized active cells forming structures called tentacles. What is the direct functional and survival advantage of this specific structural change compared to stationary Porifera?
(A) It permanently allows them to survive on completely dry land.

- (B) It enables them to actively catch their moving prey rather than depending purely on passive water currents.
(C) It physically provides a very rigid, heavy internal skeleton made of bone.
(D) It actively allows them to undergo rapid photosynthesis to produce food.

Ans : (B)

Cnidarians, such as the familiar Hydra, demonstrate a significant evolutionary advancement over simpler sponges. The distinct development of specialized tentacles empowers these aquatic organisms to actively capture their moving prey. This is a vast improvement over sponges, which are entirely sedentary and must passively rely on surrounding water currents to slowly bring tiny food particles directly into their porous bodies.

29. Read the following statement :

1. They distinctly show bilateral body symmetry.
2. They possess a massive, true, and well-developed internal body cavity.
3. Many forms have successfully adopted a specialized parasitic lifestyle.

Which of the above statements correctly describe the essential features of flatworms (Platyhelminthes)?

- (A) 1 and 2 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2, and 3

Ans : (B)

Flatworms, classified under Platyhelminthes, represent an important organizational advancement by clearly exhibiting distinct bilateral symmetry, aiding directed movement. Due to their characteristically flattened, ribbon-like bodies, they entirely lack a true internal body cavity. Additionally, numerous flatworm species have highly successfully evolved and adapted to a strictly parasitic lifestyle, firmly attaching themselves within host organisms to directly absorb vital nutrients.

30. Which specific animal phylum first introduces a highly efficient, cylindrical body design featuring a distinct organ system level of organisation with a complete digestive tract having two completely separate external openings?
(A) Porifera
(B) Cnidaria

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38. According to strict rules of binomial nomenclature introduced by Linnaeus, which statements are CORRECT?

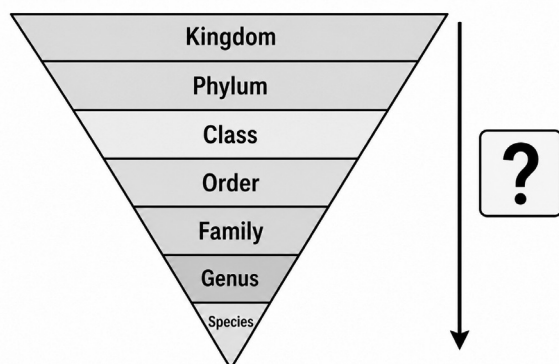
1. The scientific name uniquely consists of two distinct parts: genus and species.
2. The initial genus name must always begin with a small lowercase letter.
3. The complete scientific name is specifically written in italics when physically printed.
4. It provides a reliable universal system effectively avoiding immense regional language confusion.

- (A) 1, 2, and 4
(B) 1, 3, and 4
(C) 2, 3, and 4
(D) 1, 2, and 3

Ans : (B)

Carolus Linnaeus developed the universal binomial nomenclature system to globally standardize scientific identification. A valid scientific name strictly requires two specific parts. Rule dictates the genus name must universally begin with a prominent capital letter, not lowercase. Furthermore, to distinguish them in text, scientific names must be distinctly italicized when formally printed, effectively eliminating vast regional naming confusion worldwide.

39. Which of the following correctly identifies the biological trend represented by the downward arrow in the given classification hierarchy?



- (A) The total number of organisms in each category increases.
(B) The physical size of the organisms becomes progressively smaller.
(C) The variety of different habitats occupied by the organisms increases.
(D) The number of shared common features among organisms increases.

Ans : (D)

In biological classification, moving downwards from Kingdom to Species narrows the grouping. While the total number of organisms in each successive group decreases, the organisms within those lower groups share a much higher number of specific common features. Habitat variety and organism size do not follow a fixed directional trend in this taxonomic hierarchy.

40. Based largely on significant modern advances in microscopic genetic research and detailed DNA studies, Carl Woese (1977) formally proposed modifying the classification system into three distinct broad domains. Which of the following is strictly NOT recognized as one of these three modern domains?

- (A) Bacteria
(B) Archaea
(C) Monera
(D) Eukarya

Ans : (C)

Driven by significant advances in microscopic technology and detailed genetic DNA research, scientist Carl Woese fundamentally reorganized biological classification in 1977. He formally proposed the broader Three Domain system, effectively grouping all cellular life forms into three primary evolutionary lineages: Bacteria, Archaea, and Eukarya. Monera, while a kingdom in older systems, is completely obsolete in this modern domain classification.

Assertion (A): Deeply buried, much older geological layers of rocks generally contain structurally simpler fossilized organisms compared to newer, shallower layers.

Reason (R): Preserved fossils act as critical natural historical records physically showing how biological life has gradually changed and progressively become more complex over millions of years.

- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Fossils are the preserved, ancient remains of long-dead plants and animals found embedded in geological layers. Deeply buried, significantly

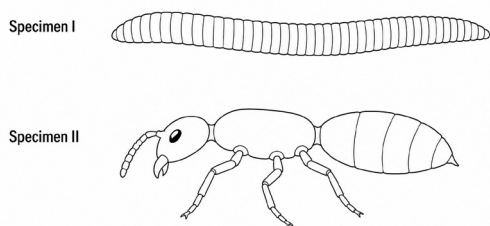
- (B) Echinodermata – Possession of a hard internal skeleton made of calcium carbonate
- (C) Porifera – Presence of highly complex, specialized true tissues
- (D) Platyhelminthes – Completely cylindrical, heavily segmented bodies

Ans : (B)

Echinoderms, a fascinating marine group including starfish and sea urchins, are uniquely characterized by possessing a tough internal skeleton. This sturdy endoskeleton is primarily composed of hardened calcium carbonate plates. In contrast, Annelids exhibit distinct body segmentation, Arthropods are defined by their jointed appendages, and simple sponges in Porifera fundamentally lack any true tissue level of structural organization whatsoever.

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- 35.** Based on the structural features shown, which classification criteria correctly separate Specimen II from Specimen I?



- (A) Presence of an internal bony skeleton in Specimen II.
- (B) Absence of body segmentation in Specimen I.
- (C) Presence of jointed appendages and distinct body regions in Specimen II.
- (D) Complete loss of bilateral symmetry in both specimens.

Ans : (C)

Specimen II exhibits a body divided into distinct regions (head, thorax, abdomen) and possesses jointed appendages, which are defining characteristic features of phylum Arthropoda. Specimen I shows uniform segmentation without any appendages, typical of phylum Annelida. Neither possesses an internal bony skeleton, and both maintain bilateral symmetry, making the other options incorrect.

- 36.**
1. They always possess a distinct vertebral column or backbone.
 2. They feature a rigid, internal supportive skeletal structure.
 3. They entirely lack any highly complex internal organ systems.
 4. They clearly show highly advanced sensory abilities and coordination.

Which of the above statements are entirely true for the group known as vertebrates?

- (A) 1, 2, and 3
- (B) 2, 3, and 4
- (C) 1, 2, and 4
- (D) 1, 3, and 4

Ans : (C)

Vertebrates represent highly advanced chordates, distinguished primarily by possessing a rigid internal skeletal structure that uniquely includes a distinct vertebral column or backbone. This crucial framework robustly supports vital organs. Furthermore, vertebrates are universally characterized by possessing highly complex, specialized organ systems, demonstrating remarkably advanced sensory capabilities, and exhibiting efficiently coordinated physiological behaviors necessary for survival in diverse, challenging environments.

- 37.** In the established taxonomic system, as we systematically move structurally downwards from the broad level of 'Kingdom' directly to the specific level of 'Species', the total number of common anatomical features shared among the organisms in that group:
- (A) Gradually decreases to a minimum
 - (B) Remains entirely constant throughout all levels
 - (C) Significantly and continuously increases
 - (D) Becomes exactly zero at the final stage

Ans : (C)

The biological classification system acts structurally like a detailed address, organizing life systematically. As you systematically progress down the rigid taxonomic hierarchy—starting from the massive, highly inclusive Kingdom level and moving toward the highly specific Species level—the individual organisms categorized within those progressively smaller groups naturally share a significantly increasing number of highly specific, common structural and genetic features.

22. When comparing a fern (Pteridophyte) directly to a moss (Bryophyte), what major internal structural advancement is distinctly observable in the fern that helps it transport water upwards?
- (A) Presence of fully developed, colorful flowers
(B) Presence of specialized vascular tissues (xylem and phloem)
(C) Presence of safely covered seeds inside fruits
(D) Complete absence of any root-like structures

Ans : (B)

Pteridophytes, such as ferns, demonstrate a major evolutionary structural advancement over simpler bryophytes. This critical development is the clear presence of specialized vascular tissues, specifically the xylem and phloem. These internal complex tissues act as efficient plumbing systems, reliably transporting essential water, vital minerals, and synthesized food throughout the entire structure of the relatively taller plant body.

23. Match List-I with List-II and select the correct

	List-I (Plant Group)		List-II (Defining Feature)
P.	Thallophyta	1.	Naked seeds exposed on cones
Q.	Gymnosperm	2.	Seeds safely enclosed within fruits
R.	Angiosperm	3.	Undifferentiated simple thallus body
S.	Bryophyta	4.	Known as amphibians of plant kingdom

option.

- (A) P-3, Q-2, R-1, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-3, R-4, S-2

Ans : (C)

Thallophytes possess a simple, entirely undifferentiated thallus-like body structure. Gymnosperms are distinctively characterized by bearing exposed, naked seeds typically situated on specialized cones. Angiosperms represent the most advanced flowering plants, bearing seeds safely enclosed within protective fruits. Bryophytes are universally recognized as the 'amphibians' of the plant kingdom due to their unique dual dependence on both land and water.

24. Which of the following is strictly NOT a general, defining characteristic of organisms accurately grouped within Kingdom Animalia?
- (A) They are complex, multicellular organisms.
(B) They are strictly heterotrophic for their nutrition.
(C) They possess a rigid, thick cell wall primarily made of cellulose.
(D) They generally exhibit coordinated behaviour and rapid response to stimuli.

Ans : (C)

Organisms classified under Kingdom Animalia are strictly characterized by being highly complex, multicellular, and entirely heterotrophic, meaning they absolutely depend on consuming other organisms for their essential nutrition. Unlike organisms in the plant kingdom, animal cells distinctly lack a rigid, supportive cell wall primarily composed of cellulose. Instead, animal cells are bounded solely by a flexible, semi-permeable cell membrane.

25. What is the fundamental primary biological role of the notochord, a highly critical defining feature used for classifying major groups within the animal kingdom?
- (A) It is a specialized organ solely responsible for digesting complex food.
(B) It acts as a crucial structural precursor for the development of the vertebral column in chordates.
(C) It forms the tough outer hard covering providing external protection in insects.
(D) It functions primarily as a sensitive sensory organ for detecting sunlight underwater.

Ans : (B)

The notochord is a fundamental biological structure found in certain animals. It is a long, flexible, rod-shaped supporting structure running along the animal's back. In advanced chordates, specifically the sub-group known as vertebrates, this highly crucial notochord acts as the vital developmental precursor, ultimately transforming into the complex, bony vertebral column, commonly referred to as the backbone or spine.

26. Aquatic sponges correctly belong to the phylum Porifera. According to classification, what is their absolute highest level of internal structural body organisation?
- (A) Basic cellular level without true tissues
(B) Complex tissue level of organisation

older rock layers typically contain fossils of much simpler primitive organisms. In sharp contrast, relatively newer, shallower layers contain increasingly complex life forms. This clear geological evidence powerfully confirms that life has slowly evolved and diversified over countless millions of years.

42. During a laboratory session, a student documents the structural features of four invertebrate animals. Identify the animal that belongs to the group of flatworms, and select the corresponding reason for its specific body shape as per the structural data provided.

Animal	Body Symmetry	Level of Organisation	Distinctive Feature
M	Asymmetrical	Cellular level	Presence of numerous pores
N	Radial symmetry	Tissue level	Tentacles with stinging cells
O	Bilateral symmetry	Organ level	Flattened body with a single opening
P	Bilateral symmetry	Organ system level	Jointed appendages and exoskeleton

- (A) Animal M; its porous body design continuously brings in food particles via water currents without specialised tissues.
 (B) Animal N; its radial symmetry helps efficiently catch prey from any direction using coordinated tissue movements.
 (C) Animal O; its flattened body architecture permits efficient diffusion of gases without requiring specialised respiratory organs.
 (D) Animal P; its rigid outer covering provides muscular support and significantly reduces water loss in terrestrial habitats.

Ans : (C)

Animal O displays bilateral symmetry, organ-level structural organisation, and a flattened body equipped with a single opening. These specific characteristics classify it as a flatworm (Platyhelminthes). This highly flattened body architecture allows the efficient diffusion of vital

gases directly across the surface, completely eliminating the need for specialised respiratory organs.

43. According to rigorous ecological study, what is a highly probable major consequence when one specific biological species entirely disappears from a complex ecosystem due to severe threats like extreme habitat loss or rapid climate change?
- (A) A completely new, identical species will immediately evolve naturally to replace it within a single year.
 (B) Other completely different species that heavily depend on it for survival may also drastically decline in number and eventually completely disappear.
 (C) The affected ecosystem instantly and permanently becomes much more biologically stable and agriculturally productive.
 (D) It has absolutely zero detectable effect on the microscopic decomposing organisms dwelling safely deep in the soil.

Ans : (B)

Within any complex ecosystem, every single species, regardless of its size, plays a deeply interconnected, vital role. When severe human activities or rapid climate changes tragically cause a specific species to completely disappear, the delicate natural balance is disrupted. Consequently, other interdependent species that critically rely on it for essential food or survival may rapidly decline and potentially face extinction themselves.

What specific scientific term precisely describes the incredibly immense, naturally occurring variety of all living organisms, ranging completely from invisible microscopic marine algae up to massive terrestrial giant trees, that is absolutely essential for sustaining life on Earth?

- (A) Ecological Biomagnification
 (B) Global Biodiversity
 (C) Chemical Bioremediation
 (D) The planetary Biosphere

Ans : (B)

The term biodiversity broadly refers to the incredibly immense and complex variety of all living organisms found on Earth. This vast concept encompasses everything from invisible microscopic bacteria to massive giant trees. This rich biological diversity is absolutely essential for keeping nature stable, maintaining functional

ecological balance, and ultimately sustaining all complex life forms residing upon our entire planet.

45. A researcher compiles the taxonomic classification of four distinct animals to study their evolutionary relationships. Based on the taxonomic hierarchy presented in the table, which two animals share the maximum number of common anatomical and physiological characteristics?

Rank	Animal 1	Animal 2	Animal 3	Animal 4
Class	Mammalia	Mammalia	Mammalia	Aves
Order	Carnivora	Carnivora	Primates	Passeriformes
Family	Felidae	Canidae	Hominidae	Corvidae
Genus	Panthera	Canis	Homo	Corvus

- (A) Animal 1 and Animal 2, because they are classified under the same Order, establishing a closer relationship than the others.
 (B) Animal 2 and Animal 3, because they both belong to Class Mammalia, sharing a fundamental biological structural blueprint.
 (C) Animal 3 and Animal 4, because they occupy vastly different ecological niches while remaining in the same taxonomic Kingdom.
 (D) Animal 1 and Animal 3, because they share identical cellular structures indicating evolution from a very recent common ancestor.

Ans : (A)

In biological classification, organisms systematically grouped in lower, more specific taxonomic categories share a significantly higher number of common features. Animal 1 and Animal 2 belong to the same Order (Carnivora), which is structurally lower than Class, establishing that they are much more closely related than any other animal pair presented.

46. The highly unexpected scientific discovery of the rare Purple Frog (*Nasikabatrachus sahyadrensis*) in the year 2003 strongly highlighted the desperate, urgent need for immediate biodiversity conservation specifically within which highly threatened geographical region of India?
 (A) The icy Northern Himalayas
 (B) The marshy Eastern Sundarbans
 (C) The biologically rich Western Ghats
 (D) The completely arid Thar Desert

Ans : (C)

The fascinating Purple Frog, formally known as *Nasikabatrachus sahyadrensis*, is a highly unique, ancient amphibian species. Its remarkable scientific discovery in 2003 brought significant global attention to its restricted habitat. This crucial finding strongly emphasized the absolutely critical, urgent need for implementing robust biodiversity conservation efforts specifically within the ecologically rich but highly threatened global hotspot of the Western Ghats.

47. The highly endangered Sangai, often famously called the unique dancing deer, is strictly endemic solely to Manipur. It relies entirely on a highly unique, incredibly fragile aquatic habitat composed completely of specialized floating grasslands. What are these vital floating grasslands locally known as?
 (A) Floating Phumdis
 (B) Northern Khadirs
 (C) Alpine Bugyals
 (D) Southern Sholas

Ans : (A)

The highly endangered Sangai, often popularly called the dancing deer, is uniquely endemic strictly to the state of Manipur in India. This rare animal absolutely relies on a highly specialized, incredibly fragile habitat composed of thick, floating masses of entangled vegetation. Locally, these unique, ecologically vital floating grasslands found within the Loktak Lake ecosystem are specifically known as phumdis.

48. How does the widespread, strict implementation of a universally accepted system of biological classification primarily and practically assist diverse scientists working globally?
 (A) It permanently strictly prevents them from ever successfully discovering any completely new, undocumented biological species.
 (B) It rigidly and strictly dictates precisely how specific wild animals must be legally hunted internationally.
 (C) It effectively allows scientists worldwide to accurately communicate and precisely discuss organisms entirely without frustrating regional naming confusion.
 (D) It practically guarantees the immediate, permanent prevention of all naturally occurring biological extinctions globally.

Ans : (C)

The primary, most practical advantage of a standardized biological classification and naming system, such as binomial nomenclature, is clear global communication. Because common names vary wildly across different languages and regions, a universal scientific name ensures that researchers worldwide can accurately identify, discuss, and study the exact same organism without any frustrating linguistic confusion or costly scientific misunderstandings arising.

49. An ecologist lists the scientific names and primary habitats of four large mammals to analyze species diversity. Based on the universally accepted rules of binomial nomenclature, which statement correctly identifies the evolutionary relationship between these organisms?

Organism	Common Name	Scientific Name	Primary Habitat
I	Snow Leopard	<i>Panthera uncia</i>	High-altitude cold mountains
II	Tiger	<i>Panthera tigris</i>	Tropical forests and grasslands
III	Indian Wolf	<i>Canis lupus</i>	Semi-arid scrublands
IV	Asian Elephant	<i>Elephas maximus</i>	Tropical deciduous forests

- (A) Organism II and Organism III are closely related species because they both inhabit similar tropical and scrubland environmental zones.
- (B) Organism I and Organism II are most closely related as they belong to the same genus, despite having adapted to vastly different habitats.
- (C) Organism III and Organism IV share a common genetic ancestry, indicating they can interbreed naturally to produce fertile offspring.
- (D) Organism I and Organism IV exhibit evolutionary similarities because their scientific names both contain highly complex Latinised structures.

Ans : (B)

Under the universally accepted rules of binomial nomenclature, the first component of a scientific name invariably designates the genus. Organisms I and II both share the genus *Panthera*,

confirming they are closely related species sharing a distinct common ancestor, even though they have successfully adapted to survive in radically different environmental habitats.

50. 1. Dense coastal mangrove forests strongly act as robust physical barriers actively against destructive cyclones.
2. High internal forest diversity can effectively act as a strong biological barrier greatly reducing tick-borne diseases.
3. Diverse microscopic organisms living in forest soils actively absorb and safely break down harmful chemical pollutants.

Which of the above statements correctly describe how highly biodiverse intact forests actively reduce the severe impact of environmental disasters?

- (A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2, and 3

Ans : (D)

Biodiverse forests provide immense, irreplaceable protection. Dense coastal mangrove forests act as robust physical barriers, significantly reducing destructive cyclone impacts. High forest biodiversity effectively acts as a crucial biological barrier, demonstrably lowering the risky transmission of dangerous tick-borne diseases. Furthermore, diverse microscopic soil organisms perform vital chemical functions by continuously absorbing, transforming, and safely breaking down harmful environmental pollutants.

51. Which exact sequence correctly completely represents the observed general evolutionary pattern of progressively increasing structural body complexity specifically among major invertebrate animal phyla?
- (A) Porifera → Cnidaria → Platyhelminthes → Nematoda
- (B) Cnidaria → Porifera → Nematoda → Platyhelminthes
- (C) Platyhelminthes → Nematoda → Porifera → Cnidaria
- (D) Nematoda → Platyhelminthes → Cnidaria → Porifera

Ans : (A)

Animal evolution demonstrates a clear, progressive increase in structural complexity. The sequence logically begins with Porifera, which possess a simple cellular organization entirely

lacking true tissues. Next, Cnidaria develop basic, functional tissues. Following this, Platyhelminthes evolve further by introducing a true organ-level structure. Finally, Nematoda display an even more advanced, highly efficient complete organ system, including a full digestive tract.

- 52.** Which remarkably detailed ancient Indian traditional texts systematically classified diverse animals specifically on the clear basis of their primary habitat (terrestrial, aquatic, and aerial), observed behaviour patterns, and vital ecological roles?
- (A) Ancient Sangam literature only
 - (B) The historic Rigveda and Brihat Samhita
 - (C) The botanical Hortus Malabaricus
 - (D) The modern published works of Birbal Sahni

Ans : (B)

India possesses a rich, profound history of early scientific observation. Ancient traditional texts, specifically the Rigveda and the highly detailed Brihat Samhita, demonstrate early taxonomic thought. They systematically classified diverse animals by carefully categorizing them based on their primary habitats—distinguishing terrestrial, aquatic, and aerial forms—alongside closely observing their distinct behavioral patterns and vital ecological roles within the environment.

- 53.** Protochordates, like the aquatic Amphioxus, are deeply considered a highly primitive, ancient type of chordate. What absolutely crucial, defining structural evolutionary change do they uniquely represent in animal body organisation?
- (A) The evolutionary complete disappearance of any central nervous system.
 - (B) The vital appearance of a flexible notochord at least once during their life, providing crucial internal physical support.
 - (C) The rapid, distinct development of a hard, heavy external shell made strictly of chitin.
 - (D) The complete evolutionary transition from dry terrestrial living to fully aquatic ocean life.

Ans : (B)

Protochordates, such as Amphioxus, occupy a crucial evolutionary position. They represent a significant structural transition by exhibiting a flexible notochord at some point during their life. This critical new structure provides essential internal physical support without restricting movement, helping scientists understand how advanced vertebrates slowly evolved from simpler,

ancient invertebrate forms possessing entirely different, less rigid supporting internal structures.

- 54.** What highly specific, advanced evolutionary structural adaptations primarily allow modern angiosperms to successfully be the absolute most diverse, dominant, and widely distributed plant group present on Earth today?
- (A) The complete evolutionary lack of internal vascular tissues and true absorptive roots.
 - (B) The complex production of attractive flowers to guarantee efficient pollinators and protective fruits to successfully spread enclosed seeds.
 - (C) Having highly specialized, thin needle-like leaves and totally exposed naked seeds located on woody cones.
 - (D) Depending completely and entirely on heavy rainfall water for their fragile male reproductive cells to swim.

Ans : (B)

Angiosperms represent the absolute peak of complex plant evolution. Their incredible global success and massive diversity stem from two major structural innovations. Firstly, they produce highly attractive flowers, drastically increasing their reproductive efficiency by attracting diverse animal pollinators. Secondly, they safely enclose their vulnerable seeds within nutritious fruits, utilizing animals, wind, or water for remarkably widespread, effective geographical dispersal.

- 55.** While visible mushrooms and common fuzzy bread moulds are excellent examples of typical multicellular organisms, which of the following is completely accurate as a prime example of a strictly unicellular fungus?
- (A) The spreading mould *Aspergillus*
 - (B) The antibiotic-producing *Penicillium*
 - (C) Common baker's Yeast
 - (D) The green aquatic *Spirogyra*

Ans : (C)

The Kingdom Fungi is fascinating because it contains both single-celled and complex multicellular organisms. While familiar forms like distinct mushrooms, growing bread moulds, and antibiotic-producing *Penicillium* are definitively large, multicellular structures composed of hyphae, yeast stands out as a unique, notable exception. Yeast is an incredibly important, naturally occurring unicellular fungus, extensively utilized

by humans in essential baking and fermentation processes.

56. Based closely on the recognized evolutionary transition of primitive plants moving to harsh land, strictly identify the specific plant group that remains entirely aquatic and completely lacks any physical differentiation into true supportive roots, tall stems, and wide leaves.
- (A) The amphibious Bryophyta
 - (B) The vascular Pteridophyta
 - (C) The seed-bearing Gymnosperm
 - (D) The simple Thallophyta

Ans : (D)

Looking closely at plant evolution, Thallophyta, commonly known as algae, represent the most primitive, basic structural forms. They are entirely restricted to wet, aquatic environments. Crucially, their incredibly simple, undifferentiated plant body, aptly termed a thallus, entirely lacks the complex structural specialization seen in later groups, meaning they completely lack true roots, supportive stems, or specialized leaves for survival.

57. Within the highly advanced vertebrates, which specific, defining structural and deeply functional physiological change specifically significantly improves the early survival chances of incredibly vulnerable young ones exclusively in the class Mammalia?
- (A) The evolutionary development of very light, highly hollow bones for sustained flight.
 - (B) The distinct, exclusive presence of functional milk-producing mammary glands.
 - (C) The specialized presence of sensitive gills for continuously breathing completely underwater.
 - (D) The hard, protective rough scales entirely covering their outer external skin.

Ans : (B)

Vertebrates have evolved numerous remarkable structural adaptations to guarantee survival across diverse environments. Within the specific mammalian group, a highly distinct, defining evolutionary advancement is the clear presence of specialized, functional mammary glands. These unique internal structures produce nutritious milk, significantly improving the early survival rate, healthy growth, and crucial developmental stages of their highly vulnerable, newly born young offspring.

58. A taxonomist newly discovers a rare species of large, roaring cat physically closely related to the known tiger (*Panthera tigris*) and the African lion (*Panthera leo*). According to strict binomial nomenclature rules, what exact word must be the first word of its officially assigned scientific name?
- (A) Tigris
 - (B) Leo
 - (C) Panthera
 - (D) Felidae

Ans : (C)

The precise binomial nomenclature system categorizes life logically. The fundamental first word of any scientific name clearly denotes the organism's broader Genus. Because this newly discovered, roaring cat species shares significant, fundamental structural similarities and very close evolutionary genetic ties with both the known tiger and lion, it must accurately be classified under the exact same shared genus, which is *Panthera*.

59. The microscopic organisms depicted are single-celled and possess a true membrane-bound nucleus. Some of them can photosynthesize while others cannot. Based on these cellular characteristics, to which kingdom do these organisms belong?
- (A) Monera
 - (B) Protista
 - (C) Fungi
 - (D) Plantae

Ans : (B)

The organisms are unicellular and eukaryotic, placing them in the kingdom Protista. Unlike Monera, they have a true membrane-bound nucleus. Unlike Fungi and Plantae, they are predominantly single-celled without forming multicellular tissue structures. Their ability to exhibit both autotrophic and heterotrophic modes of nutrition further supports their placement in this diverse kingdom.

60. The organism shown plays a crucial ecological role as a decomposer. What is the primary constituent of the cell wall in this specific type of organism?
- (A) Cellulose
 - (B) Lignin
 - (C) Chitin
 - (D) Pectin

Ans : (C)

The depicted organism is a mushroom, which belongs to the kingdom Fungi. Members of this kingdom are characterized by having rigid cell walls composed primarily of chitin. In contrast, organisms in the kingdom Plantae possess cell walls made of cellulose, while animal cells completely lack a cell wall structure entirely.

61. The given images display a specific plant and the cross-section of its stem highlighting specialized internal tissues. What significant evolutionary advancement allows this plant to survive on land compared to simpler plant forms like mosses?
- (A) Development of flowers for efficient reproduction
 - (B) Presence of vascular tissues for active transport
 - (C) Production of seeds securely enclosed in fruits
 - (D) Ability to reproduce entirely without external water

Ans : (B)

Ferns belong to Pteridophyta, which are the first terrestrial plants to possess specialized vascular tissues, namely xylem and phloem, for conducting water and food. Unlike simpler bryophytes, this structural adaptation allows them to grow taller. However, they do not produce flowers or seeds, and they still require moisture for successful reproduction.

62. The internal structure of the organism displays a body divided into repeating segments alongside a distinct body cavity. How does this structural organization directly benefit the organism in its natural habitat?
- (A) It provides a rigid external skeleton to prevent severe water loss.
 - (B) It allows for greater flexibility and highly precise control of movements.
 - (C) It eliminates the fundamental need for a specialized digestive system.
 - (D) It enables the organism to survive exclusively as an internal parasite.

Ans : (B)

The organism is an earthworm, representing the phylum Annelida. Its body exhibits extensive segmentation and a true body cavity. This segmentation allows different muscle sections to contract independently, providing enhanced flexibility and precise movement coordination essential for burrowing. Unlike arthropods, it entirely lacks a rigid protective external skeleton for support.

63. The diagram illustrates the hierarchical classification of a specific organism. Which of the following statements accurately describes the fundamental relationship between the organisms categorized at level 'P' compared to those at level 'Q'?
- (A) Organisms at level P share significantly more specific anatomical features than those at level Q.
 - (B) Organisms at level Q are closely related and capable of interbreeding to produce fertile offspring.
 - (C) Level P represents the specific Genus while level Q represents the broader Kingdom grouping.
 - (D) The absolute number of different organisms decreases as one moves from level Q to level P.

Ans : (B)

The hierarchical pyramid narrows from the Kingdom level at the broad top (P) to the Species level at the pointed base (Q). Organisms at the Kingdom level share few broad characteristics. Conversely, the Species level comprises closely related individuals that share maximum specific similarities and can successfully interbreed to reproduce.

VERY SHORT ANSWER

64. What are endemic species?

Ans :

Endemic species are organisms that are restricted to specific geographical regions of the world and are not found naturally anywhere else on the Earth.

65. Name two endemic species found only in India.

Ans :

Two examples of endemic species found only in India are the Nilgiri tahr and the Lion tailed macaque, occupying very restricted geographical habitats.

66. What is the significance of biodiversity hotspots?

Ans :

Biodiversity hotspots are significant because they support a remarkably large number of endemic species and play an absolutely crucial role in global biodiversity conservation.

67. Define biological classification.

Ans :

Biological classification is the systematic scientific process of grouping diverse living organisms based on their shared similarities and differences to study them easily.

68. What causes the evolution of new forms of biodiversity?

Ans :

New forms of biodiversity evolve because small differences among individuals help them adapt to changing environmental conditions, accumulating over successive biological generations.

69. State two broad criteria used by scientists to classify living organisms.

Ans :

Scientists classify living organisms primarily based on their specific cell structure, such as being prokaryotic or eukaryotic, and their main mode of nutrition.

70. Why did the two kingdom classification system proposed by Linnaeus create confusion?

Ans :

The two kingdom system created confusion because it grouped highly dissimilar organisms together, failing to distinguish between bacteria and complex multicellular green plants.

71. Who proposed the five kingdom classification system and in which year?

Ans :

The widely accepted five kingdom biological classification system was officially proposed by the scientist Robert Whittaker during the pivotal year of nineteen sixty nine.

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72. Give one distinguishing characteristic of organisms belonging to Kingdom Monera.

Ans :

Organisms belonging to Kingdom Monera are distinctly characterized by being single celled prokaryotes that completely lack a well defined membrane bound true nucleus.

73. What is the cell wall of some protists made up of?

Ans :

The protective cell wall present in certain single celled eukaryotic organisms belonging to the kingdom Protista is primarily composed of complex carbohydrate called cellulose.

74. What is the ecological role of some protists in aquatic environments?

Ans :

In aquatic environments, some autotrophic protists act as crucial oxygen producers, while heterotrophic protists perfectly serve as an important nutritious food source for small animals.

75. Why are fungi considered important decomposers in our ecosystem?

Ans :

Fungi are fundamentally considered important decomposers because they efficiently break down complex organic matter from dead organisms, directly returning essential mineral nutrients into soil.

76. State one structural difference between the cell walls of plants and fungi.

Ans :

The major structural difference is that a green plant cell wall mainly contains cellulose, whereas a fungal cell wall is entirely constructed using chitin.

77. Why are bryophytes commonly known as the amphibians of the plant kingdom?

Ans :

Bryophytes are called plant amphibians because although they successfully colonize moist land, they still absolutely require liquid water for their male reproductive cells to swim.

78. What is the significance of vascular tissues in pteridophytes?

Ans :

The clear presence of specialized vascular tissues like xylem and phloem in pteridophytes significantly allows highly efficient transport of water throughout their larger plant bodies.

- 79.** State one distinct difference between gymnosperms and angiosperms regarding their seeds.

Ans :

Gymnosperms produce completely naked seeds that are exposed on cones, whereas angiosperms tightly enclose their developing seeds within specially formed protective fleshy fruit structures.

- 80.** Give one example of a symbiotic relationship found in the kingdom Plantae.

Ans :

Lichens represent a unique symbiotic relationship where an autotrophic alga provides photosynthesised food while a heterotrophic fungus carefully offers essential shelter and absorbed nutrients.

- 81.** What is a notochord in the context of animal classification?

Ans :

A notochord is a distinctly flexible rod shaped supporting structure found in early chordates that physically acts as a vital precursor for the vertebral column.

- 82.** How is the body symmetry of Platyhelminthes different from that of Porifera?

Ans :

Platyhelminthes exhibit advanced bilateral symmetry where bodies closely divide into identical halves, while Porifera generally display distinctly asymmetrical simple body structures completely lacking organized tissues.

- 83.** What advantage does a hard external skeleton provide to arthropods?

Ans :

A rigid external skeleton offers vital physical protection, significantly reduces dangerous bodily water loss, and strongly supports attached muscle tissues for harsh dry environments.

- 84.** What is the defining characteristic of organisms belonging to the phylum Annelida?

Ans :

Organisms in the phylum Annelida are clearly defined by having highly segmented cylindrical bodies, which allows much greater biological flexibility and highly precise locomotive movements.

- 85.** Describe the internal structure of Echinodermata in one sentence.

Ans :

Members of Echinodermata remarkably possess a tough internal skeleton mainly made of rigid calcium carbonate, providing excellent structural protection despite completely lacking a true notochord.

- 86.** List the seven main levels of hierarchical classification starting from the broadest group.

Ans :

The seven main hierarchical levels of biological classification, perfectly ordered from broadest to most specific, are Kingdom, Phylum, Class, Order, Family, Genus, and finally Species.

- 87.** Why did scientists introduce the binomial system of biological nomenclature?

Ans :

Scientists introduced the binomial nomenclature system to successfully establish a universally accepted scientific naming method, effectively avoiding massive communication confusion caused by regional common names.

- 88.** State one important rule for writing a scientific name under binomial nomenclature.

Ans :

According to strict binomial nomenclature rules, the scientific biological name must be written in italics when printed, or clearly underlined separately when handwritten on paper.

- 89.** Who proposed the three domain system and what was it based on?

Ans :

The three domain biological classification system was initially proposed by scientist Carl Woese in nineteen seventy seven, based entirely on detailed genetic cellular DNA differences.

- 90.** What evidence do fossils provide about the evolution of biodiversity?

Ans :

Preserved fossils fundamentally serve as critical natural records, clearly demonstrating how incredibly ancient simple organisms gradually changed into highly complex modern biological life forms eventually.

91. What would happen if a species abruptly disappears from an ecosystem?

Ans :

If a particular species abruptly disappears, many other intimately dependent organisms might terribly suffer, heavily disrupting the delicate natural ecological balance of the entire ecosystem.

92. Why are forests considered vital biological barriers against specific animal diseases?

Ans :

Highly diverse forest environments effectively act as distinct biological barriers because extremely abundant wildlife effortlessly provides numerous alternative hosts, heavily reducing severe human viral infections.

93. What is the significance of discovering the Purple Frog in the Western Ghats?

Ans :

Discovering the rare Purple Frog profoundly helped scientists clearly understand highly isolated ancient amphibian groups, strongly highlighting the urgent absolute necessity for intense biodiversity conservation.

SHORT ANSWER QUESTIONS

94. Explain the concept of biodiversity hotspots with the help of examples from India.

Ans :

Biodiversity hotspots are regions that support an exceptionally large number of endemic species and have simultaneously experienced significant habitat loss. These areas are crucial for worldwide biodiversity conservation. Endemic species are those entirely restricted to specific geographic regions and not found naturally anywhere else. In India, examples of such highly diverse and threatened regions include the Western Ghats, the Indo-Burma region, the Himalayas, and Sundaland. Protecting these hotspots ensures the survival of diverse organisms, maintains stable natural food webs, and sustains healthy functioning ecosystems globally.

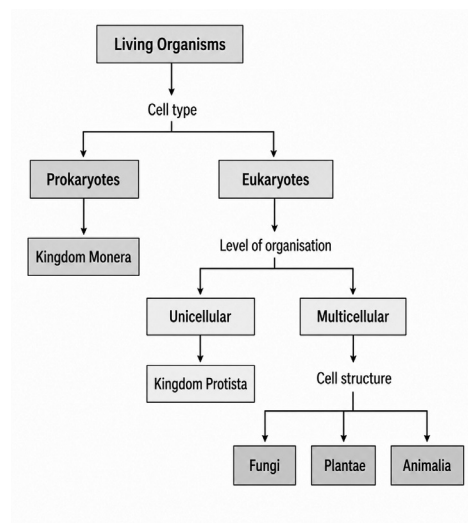
95. What is biological classification? State any two ways in which it helps scientists study biodiversity.

Ans :

Biological classification is the systematic scientific grouping of living organisms based on their shared physical similarities, structural differences, and intricate evolutionary relationships. It provides a structured framework to comprehend the vast diversity of life. Firstly, it makes the study of millions of living organisms much more organized, systematically structured, and scientifically manageable. Secondly, it helps us deeply understand the complex interrelationships and common evolutionary connections among different species, allowing researchers to rapidly identify newly discovered organisms and recognize endangered species that desperately require immediate conservation efforts.

96. Draw a flowchart showing the broad classification of living organisms into five kingdoms based on cell type and body organization. On what basis is Monera separated from others?

Ans :



Kingdom Monera is separated from all other biological kingdoms primarily based on its primitive cell type. Organisms in Monera are exclusively prokaryotic, meaning they possess a primitive nucleus that is absolutely not bound by any nuclear membrane. Unlike advanced eukaryotes, they completely lack membrane-bound internal cell organelles. This fundamental evolutionary difference in internal cellular structure distinctly separates primitive bacteria and cyanobacteria in Kingdom Monera from all organisms found in Protista, Fungi, Plantae, and Animalia, which consistently possess well-defined, membrane-bound eukaryotic nuclei and complex cellular machinery.

97. A student claims that all multicellular eukaryotic organisms belong to either Kingdom Plantae or Kingdom Animalia. Is this correct? Justify your answer using the five-kingdom classification system.

Ans :

This student's claim is completely incorrect. While Kingdom Plantae and Kingdom Animalia certainly consist of multicellular eukaryotic organisms, they are definitely not the only ones. Kingdom Fungi also consists primarily of multicellular eukaryotes, such as common mushrooms and bread moulds. Fungi are distinct because they have rigid cell walls made of chitin, unlike plant cell walls predominantly made of cellulose. Additionally, fungi are heterotrophic saprophytes that absorb nutrients from dead organic matter, fundamentally distinguishing them from autotrophic plants and heterotrophic animals lacking cell walls entirely.

98. Compare organisms belonging to Kingdom Monera and Kingdom Protista with respect to their cell type and body organization.

Ans :

Kingdom Monera and Kingdom Protista are both essential major groups in the biological classification system, but they differ fundamentally in their internal cellular structure. Organisms in Monera, such as various bacteria, are primitive prokaryotes. They possess a primitive, unbounded central nucleus and completely lack membrane-bound organelles. In stark contrast, organisms in Protista, like Amoeba and Paramecium, are advanced eukaryotes featuring a true, membrane-bound nucleus and highly distinct functional cellular organelles. Regarding overall body organization, both biological kingdoms predominantly consist of single-celled, strictly unicellular microscopic organisms.

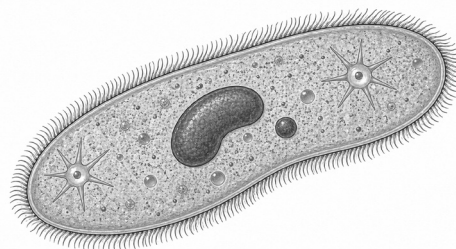
99. Explain why fungi are considered ecologically important decomposers in natural environments.

Ans :

Fungi play an extremely crucial and indispensable ecological role as natural decomposers in terrestrial environments. Being heterotrophic organisms, they cannot synthesize their own food but instead feed relentlessly on dead and decaying organic matter, such as fallen leaves, dead animals, and rotting wood. They actively release special biological enzymes that efficiently break down complex organic matter

into much simpler, soluble substances outside their bodies. Through this continuous decomposition process, fungi help recycle vital essential nutrients and minerals back into the soil, significantly maintaining overall soil fertility.

100. Study the given microscopic illustration of an organism.



Identify the biological kingdom to which this organism belongs. What cellular feature justifies this classification?

Ans :

The illustrated organism is a Paramecium, which strictly belongs to the Kingdom Protista. This specific kingdom comprises primarily single-celled eukaryotic organisms adapted to various environments. The main distinguishing cellular feature that justifies its exact placement in Protista is the prominent presence of a true, membrane-bound nucleus and other complex internal organelles, which are clearly visible within its highly organized cellular structure. Unlike members of Monera, which are also single-celled but fundamentally lack a defined nucleus, this advanced organism exhibits a very sophisticated eukaryotic cell organization.

101. What are bryophytes? Why are they commonly referred to as the 'amphibians of the plant kingdom'?

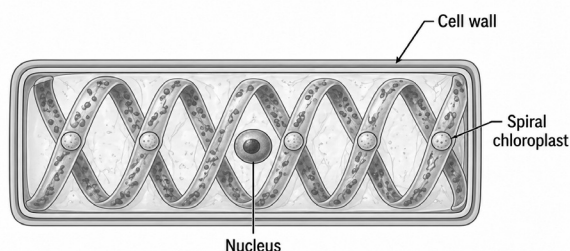
Ans :

Bryophytes are a fascinating group of primitive terrestrial plants that exhibit a slight visible differentiation in their body parts, typically forming root-like structures called rhizoids alongside simple stem-like or leaf-like structures, though they entirely lack true vascular tissues. Common examples include various mosses and liverworts. They are widely referred to as the amphibians of the plant kingdom because they successfully live on moist land but remain completely dependent

on external water for their sexual reproduction. Their male reproductive cells must physically swim through water droplets to achieve fertilization.

- 102.** Draw a labelled diagram of Spirogyra. Why is this specific organism placed in the division Thallophyta?

Ans :



Spirogyra is placed within the plant division Thallophyta because it possesses a very primitive, simple, and physically undifferentiated plant body known structurally as a thallus. Its basic structural design completely lacks the complex differentiation into true functional roots, stems, or leaves commonly seen in higher land plants. Furthermore, it completely lacks specialized internal vascular tissues like xylem and phloem. This incredibly simple thallus design safely facilitates the direct, efficient absorption of water, essential dissolved nutrients, and vital respiratory gases directly from its surrounding moist aquatic habitat.

- 103.** Compare gymnosperms and angiosperms with respect to their seed structure and specific reproductive features.

Ans :

Gymnosperms and angiosperms are both advanced, incredibly complex seed-bearing land plants, yet they constantly display stark fundamental differences in their specialized reproductive mechanisms. Gymnosperms are perfectly adapted to harsh, dry environmental conditions and produce completely naked seeds, meaning their seeds develop fully exposed directly on the surface of woody cones without any outer protective covering. Conversely, angiosperms represent highly evolved modern flowering plants. They possess complex colourful floral structures designed to actively attract specific animal

pollinators, and their developing seeds always remain completely enclosed within protective fruits.

- 104.** Describe why taller land plants require specialized internal transport tissues like xylem and phloem for their survival.

Ans :

As primitive plants gradually evolved to aggressively colonize land and grow significantly taller, their structural complexity drastically increased, heavily distancing their upper photosynthetic leaves from their essential water-absorbing deep roots. Taller plants strictly require highly specialized internal transport tissues to bridge this massive structural gap efficiently. Xylem tissue is absolutely essential to constantly conduct water and dissolved minerals from deep soil upward against gravity. Simultaneously, phloem tissue is strictly necessary to actively transport the synthesized food from the leaves downward to deeply nourish all non-photosynthetic roots.

- 105.** Describe the defining structural features of the phylum Arthropoda that help them successfully survive in incredibly diverse environments.

Ans :

Phylum Arthropoda represents the largest and most successful group of animals globally, characterized primarily by possessing highly specialized jointed appendages and distinctly segmented bodies. A defining structural feature that heavily contributes to their incredibly widespread survival is the continuous presence of a remarkably hard, rigid external skeleton known universally as an exoskeleton. This tough protective outer covering effectively shields their internal delicate organs from dangerous physical injury and significantly reduces fatal water loss, brilliantly allowing them to thrive even in extremely dry, hot, and highly exposed environments.

- 106.** What is binomial nomenclature? State any two important rules strictly followed while writing these specific scientific names.

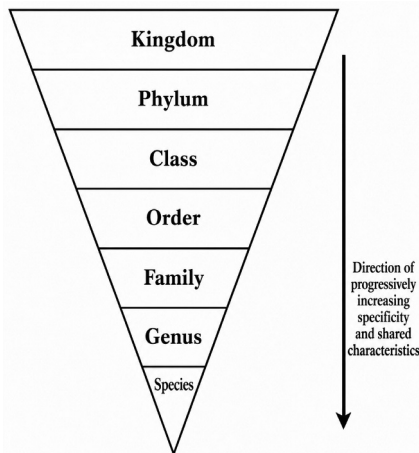
Ans :

Binomial nomenclature is a highly precise, universally accepted scientific system of naming living organisms, originally introduced by Carolus Linnaeus, where every single organism receives a

128. (a) Draw a well-labelled diagram representing the hierarchical nature of biological classification from the broadest Kingdom down to Species?
- (b) Explain the core concept behind this hierarchical classification?
- (c) Which specific taxonomic group possesses the largest number of organisms, and which exhibits the maximum shared characteristics?

Ans :

(a)



- (b) Hierarchical classification is a highly systematic scientific method of purposefully organising diverse living organisms into successive descriptive levels or ranks firmly based on their shared evolutionary characteristics. This logical step-by-step arrangement functions precisely like a detailed address, starting from incredibly broad, inclusive groups and progressively narrowing down to exceptionally smaller, highly specific descriptive categories.
- (c) In this structured hierarchy, the Kingdom represents the absolute highest taxonomic level and consequently contains the largest overall number of distinct organisms, though they share only the most basic functional traits. Conversely, the Species represents the absolute lowest and most highly specific level in the descriptive hierarchy. Therefore, while the species group contains the fewest total number of unique individuals compared to the broader ranks, these specific organisms exhibit the absolute maximum number of uniquely common physical and genetic characteristics, successfully allowing them to interbreed naturally.

129. (a) Compare the contrasting reproductive adaptations vividly seen in gymnosperms and angiosperms?
- (b) Based on their highly evolved physical structures, explain why angiosperms are universally considered the most extraordinarily successful and geographically diverse plant group currently existing on Earth?

Ans :

- (a) Gymnosperms are hardy plants remarkably well-adapted to survive in exceedingly cold and incredibly dry terrestrial regions. They primarily reproduce through distinct seeds that remain completely naked and fully exposed on protective structural cones, entirely lacking any enclosing flowers or fleshy fruits. Conversely, angiosperms feature a tremendously advanced, highly efficient reproductive system prominently characterised by the glorious development of complex, colourful flowers and protective fruits. In all angiosperms, the vital seeds are safely and securely enclosed within the protective internal layers of a developed fruit.
- (b) Angiosperms are widely and universally considered the most phenomenally successful and extraordinarily diverse plant group on Earth directly due to these incredibly specific evolutionary reproductive adaptations. The exceptionally bright colours and sweet nectars of their diverse flowers efficiently attract various necessary insects, greatly ensuring highly successful biological pollination across vast geographical distances to ensure remarkable ongoing species continuity.

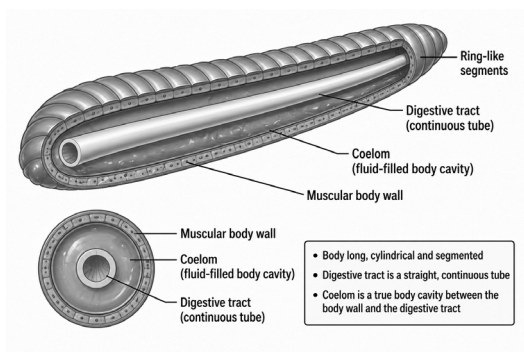
130. (a) What are the prominent defining physical features of diverse organisms belonging to the vast phylum Arthropoda?
- (b) Explain how their unique external body structure provides them with a massive evolutionary survival advantage over the generally soft-bodied organisms securely placed in the phylum Mollusca?

Ans :

- (a) Organisms actively belonging to the vast phylum Arthropoda form the absolute largest group in the entire animal kingdom and are uniquely characterised by the highly visible presence of distinct jointed appendages and clearly segmented bodies. A crucial,

The systematic system begins at the top with the 'Kingdom', definitively representing the broadest category encompassing numerous organisms sharing only fundamental basic biological traits. As classification predictably moves downwards through progressively much narrower categories—Phylum, Class, Order, Family, and Genus—the grouped organisms share increasingly more highly specific structural features, finally culminating strictly at the exclusive 'Species' level.

111. Observe the given diagram of an animal's internal structure.



Identify its specific phylum. How does this specific segmented body design provide a strong advantage in locomotion?

Ans :

The illustrated organism definitely belongs to the advanced invertebrate phylum Annelida, commonly known as segmented worms, clearly evidenced by its distinct cylindrical body beautifully divided into highly repetitive ring-like segments and a true body cavity. This remarkably segmented body design provides a truly tremendous physical advantage by allowing for incredibly greater muscular flexibility and exceptionally precise, highly coordinated control over its complex movements. Each internal segment structurally operates somewhat independently with its own specialized muscle sets, brilliantly helping the earthworm efficiently burrow and safely navigate through dense soils.

112. What is a notochord? How do protochordates differ fundamentally from true vertebrates regarding the progressive development of this structure?

Ans :

A notochord is a remarkably flexible, solid rod-shaped skeletal structure positioned longitudinally

dorsally in all chordates, which beautifully separates the delicate nervous tissue from the underlying gut while providing incredibly vital internal physical support. Protochordates, representing a very primitive evolutionary chordate transition, possess this simple supportive notochord only during certain specific developmental stages of their life cycle without ever developing a bony skeleton. In incredibly stark fundamental contrast, advanced true vertebrates possess this notochord exclusively during early embryonic stages, systematically replacing it completely with a complex bony vertebral column.

113. What would happen to our scientific understanding of evolutionary relationships if all unicellular organisms were permanently grouped blindly into a single classification kingdom? Explain.

Ans :

If absolutely all unicellular organisms were permanently grouped carelessly into a single overarching kingdom, our crucial scientific understanding of fundamental deep evolutionary relationships would become severely distorted and hopelessly confused. Unicellular organisms exhibit incredibly drastically different foundational cellular organizations. Grouping them together would mistakenly force primitive prokaryotic bacteria, which completely lack a distinct membrane-bound nucleus, into the exact same category as highly advanced eukaryotic protists like Amoeba. Such a deeply flawed system would completely ignore the incredibly critical evolutionary milestone of true complex nucleus development entirely.

114. Describe the incredibly unique reproductive features that essentially make angiosperms the most diverse and highly complex plant group on Earth.

Ans :

Angiosperms represent the absolute most advanced and structurally complex body organization naturally found within the entire plant kingdom. Their remarkably unparalleled biological diversity largely stems from their highly developed efficient vascular transport tissues and incredibly unique reproductive adaptations. Crucially, they aggressively reproduce sexually through highly specialised, distinctly attractive structures called flowers, which dynamically attract various animal pollinators, significantly increasing their overall

anywhere else in the world. He also mentioned that this forest region supports an enormous variety of life forms but is facing severe habitat loss due to human activities, making its protection extremely crucial for the planet's ecological balance.

QUESTIONS:

- What term is used to describe species like the Lion-tailed macaque that are restricted to a specific region?
- Why is the Western Ghats classified as a global biodiversity hotspot?
- Explain the ecological consequence if these endemic species lose their natural habitat completely.

Ans :

- They are called endemic species.
- The Western Ghats is classified as a biodiversity hotspot because it supports a exceptionally large number of endemic species and is currently undergoing significant habitat loss.
- If these species lose their habitat completely, they will face extinction since they are not found naturally anywhere else. This disappearance would disrupt local food chains and reduce the overall stability and health of the forest ecosystem.

- 134.** In the school laboratory, Reena and her classmates were given a mixture of pond water containing various unknown organisms. The teacher asked them to group the organisms systematically. Reena first separated the organisms based on whether they consisted of a single cell or multiple cells. Next, for the multicellular ones, she checked under the microscope to see if their cells had a rigid cell wall. Finally, she observed their mode of nutrition, separating those that could photosynthesise from those that consumed other organisms for food. This step-by-step sorting made studying the vast variety of pond life much easier.

QUESTIONS:

- What is the fundamental advantage of classifying organisms systematically as Reena did?
- Identify two major criteria Reena used to sort the organisms in the laboratory.
- If Reena found a multicellular organism with a cell wall that performs photosynthesis, to which kingdom would it belong?

- Why is cell structure considered a more basic characteristic for classification than the mode of nutrition?

Ans :

- Systematically classifying organisms makes the study of diverse living beings more organised, helps us understand the evolutionary relationships among them, and makes identifying newly discovered organisms easier.
- Reena used the level of organisation (unicellular or multicellular), the presence or absence of a cell wall, and the mode of nutrition (autotrophic or heterotrophic) as her criteria.
- It would belong to the Kingdom Plantae.
- Cell structure determines the fundamental design of an organism's body. Whether a cell is a prokaryote or eukaryote dictates its ability to form complex multicellular tissues. Therefore, it is a broader and more basic division than how the fully formed organism acquires its food.

- 135.** A local dairy farmer, Ramesh, decided to manage cow dung waste by setting up a biogas plant. An agricultural scientist explained that certain microscopic, single-celled organisms thrive in the oxygen-free environment of the plant to break down the waste and produce gas. Meanwhile, Ramesh's daughter collected some stagnant water from a nearby ditch. Under her school microscope, she observed tiny single-celled organisms moving around. Unlike the gas-producing organisms in her father's plant, the ones in her water sample had a distinct, membrane-bound structure inside them containing their genetic material.

QUESTIONS:

- To which kingdom do the biogas-producing organisms in Ramesh's plant belong?
- What specific scientific term describes the cellular organisation of the organisms producing the biogas?
- Identify the kingdom of the single-celled organisms found in the stagnant water by Ramesh's daughter.
- Differentiate between the microscopic organisms found in the biogas plant and those in the stagnant water based on their cell structure.

- 119.** Draw a labelled diagram of Echinodermata (e.g., Starfish). Explain its distinct structural mechanism for internal physical support despite completely lacking a notochord.

Ans :



Echinodermata, such as the common marine starfish, are exclusively complex marine invertebrates that wonderfully exhibit highly advanced body designs. Although they completely naturally lack a supportive notochord, they have successfully developed a truly unique alternative mechanism for vital structural support. They possess a remarkably hard, rigid internal skeleton primarily composed entirely of tough calcium carbonate structures securely located directly beneath their spiny protective skin. This highly advanced internal endoskeleton provides incredibly excellent protection and wonderfully facilitates highly controlled movement across rough marine environments efficiently.

- 120.** A researcher fiercely asserts that studying the traditional knowledge of indigenous local communities is entirely useless for modern scientific classification and conservation. Do you agree? Justify.

Ans :

I absolutely strongly disagree with this incredibly narrow, highly dismissive assertion. Deep traditional ecological knowledge historically held by indigenous local communities is truly incredibly valuable and consistently perfectly complements modern complex scientific understanding wonderfully. For many centuries, knowledgeable farmers and isolated tribal communities have constantly relied deeply on incredibly practical observational knowledge to accurately identify, cleverly classify, and

sustainably safely conserve massively diverse crop varieties based precisely on essential characteristics like rare drought tolerance, brilliantly proving that traditional indigenous wisdom forms a deeply excellent scientific foundation.

- 121.** Describe the specific chronological sequence of essential steps strictly required to perfectly make a hay infusion slide to easily observe living protists.

Ans :

To successfully prepare a high-quality hay infusion, first carefully collect a small fresh sample of cut lawn grass or dried fodder. Place this organic material directly into a distinctly clean glass bottle, filling it gently about one-fourth full. Next, entirely fill the glass bottle completely with raw stagnant pond water, securely covering the bottle's open mouth tightly with a clean muslin cloth tied firmly with thread. Leave the bottle totally undisturbed peacefully for an entire week before carefully extracting a single drop for microscopic observation.

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- 122.** Explain precisely how dense forests characterized by incredibly high natural biodiversity actively act as formidable protective barriers against severe environmental disasters and dangerous diseases.

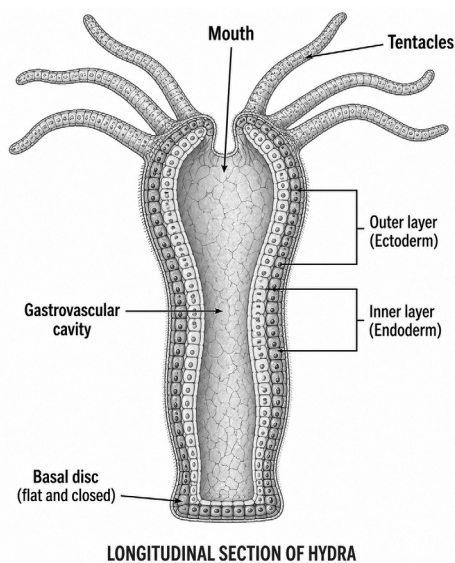
Ans :

Dense natural forests fundamentally characterized by incredibly rich, highly complex biodiversity continuously function brilliantly as truly formidable physical, biological, and complex chemical barriers against numerous severe environmental challenges. Physically, incredibly diverse ecosystems like thick coastal mangrove forests naturally create incredibly strong barriers that significantly absorb the highly destructive physical impact of severe oceanic cyclones. Biologically, incredibly rich forest animal diversity effectively acts essentially as a powerful natural buffer against zoonotic diseases, as the vast abundance of varied animal hosts critically prevents dangerous viruses from replicating rapidly.

completely unique two-part scientific name. This brilliant system completely eliminates the massive global confusion typically caused by numerous varied regional common names. According to universally established rules, the first part officially represents the genus and must always begin with a distinct capital letter. The second specific part clearly indicates the unique species and is consistently written entirely in standard lower case letters.

107. Draw a simple diagram showing the longitudinal section of Hydra. How does its body design show a structural advancement over Porifera?

Ans :



Hydra strictly belongs to the invertebrate phylum Cnidaria, which beautifully exhibits clear tissue-level body organization, clearly marking a very significant evolutionary structural advancement over the much simpler cellular-level organization fundamentally found in Porifera. Unlike primitive sponges, which essentially rely entirely on passive water currents continuously filtering through numerous tiny pores to blindly capture food particles, Hydra possesses highly specialized functional cells beautifully organized into working tissues. It features specialized flexible tentacles allowing the organism to intentionally and actively capture passing prey, clearly demonstrating advanced active feeding behaviours.

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108. What is bilateral symmetry? How does this structural advancement help flatworms (Platyhelminthes) survive in their specific environments?

Ans :

Bilateral symmetry is a highly advanced internal body organization where an active organism's entire body can be perfectly divided into two identical left and right halves along a single central longitudinal plane. Flatworms represent the very first invertebrate group to prominently exhibit this extremely significant structural advancement. This beautifully distinct left-right symmetry brilliantly allows for much better internal coordination of developing organs and highly efficient directional movement. Consequently, it easily enables the flatworm to move very purposefully through environments with a distinctly clear head-tail orientation, locating host tissues.

109. A student strongly asserts that birds and bats are very closely related because they both possess large functional wings and can fly efficiently. Do you agree with this classification? Justify.

Ans :

I completely disagree with this superficial biological assertion. In formal scientific biological classification, mere external physical similarities like the shared functional ability to fly absolutely do not dictate true underlying evolutionary relationships. While both definitely possess functional wings, their deep fundamental internal anatomical structures and unique reproductive methods firmly place them in entirely different vertebrate classes. Birds strictly belong to class Aves; they uniquely possess feathers and aggressively reproduce by laying shelled eggs. Bats, however, strictly belong to class Mammalia, actively giving birth to live young.

110. Explain the strict hierarchical nature of biological classification using the relevant categories sequentially from Kingdom down to Species.

Ans :

Biological classification inherently follows a highly structured, distinctly step-by-step hierarchical order, brilliantly functioning much like a highly precise geographical address for accurately identifying living organisms globally.

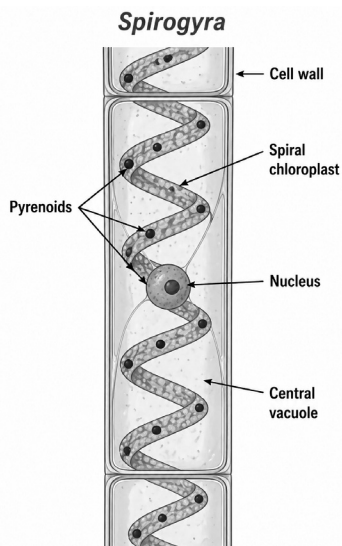
the Nilgiri tahr or the Lion-tailed macaque in India. Regions that consistently support a remarkably high number of such unique endemic species but have simultaneously suffered significant historical habitat loss are formally classified as biodiversity hotspots. The Western Ghats and the mighty Himalayas are prominent examples of such critical hotspots within India.

- (b) Unfortunately, these vital natural ecosystems face incredibly severe threats primarily due to relentless human interference. Destructive activities like extensive deforestation for commercial agriculture, rapid urbanisation, and heavy pollution directly destroy the fragile natural habitats of these species. Furthermore, accelerating climate change drastically alters local temperature and rainfall patterns, making basic survival extremely difficult for organisms heavily adapted to specific local environmental conditions.

126. (a) Draw the cellular structure of Spirogyra?
 (b) How does the fundamental body organisation of the division Thallophyta significantly differ from that of Pteridophyta?
 (c) Explain the specific biological reason why bryophytes are commonly referred to as the amphibians of the plant kingdom?

Ans :

- (a)



- (b) Thallophytes, such as Spirogyra, possess the absolute simplest plant body organisation, which is completely undifferentiated and forms a basic structure called a thallus. They

genuinely lack true roots, stems, and leaves, relying primarily on direct cellular absorption of essential nutrients from their immediate moist surroundings. In sharp contrast, pteridophytes demonstrate a much more advanced and highly complex level of structural organisation. They are the prominent first terrestrial plants to possess properly differentiated true roots, stems, and leaves, alongside specialised internal vascular tissues called xylem and phloem for the rapid transport of water and food.

- (c) Meanwhile, bryophytes curiously occupy an evolutionary middle ground and are commonly referred to as the amphibians of the plant kingdom. This designation exists because, although these specific plants successfully live on moist land, they still absolutely depend on external water for the successful swimming of male reproductive cells.

127. (a) Differentiate clearly between the fundamental body design of organisms in phylum Porifera and those in phylum Cnidaria?
 (b) How does the presence of specialised cellular structures in cnidarians give them a significant evolutionary advantage over simple sponges in aquatic environments?

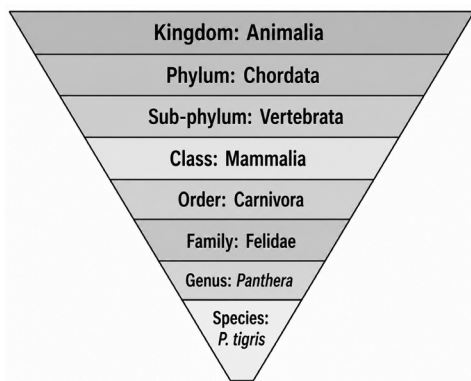
Ans :

- (a) The body design of Porifera, commonly known as sponges, represents the absolute simplest level of multicellular organisation entirely without any true tissues or distinct functional organs. Their cylindrical bodies are prominently characterised by numerous tiny pores that effortlessly allow surrounding water to flow continuously, bringing in vital dissolved oxygen and suspended microscopic food particles. They are firmly sessile creatures permanently attached to a hard aquatic surface. Conversely, Cnidarians, such as Hydra and jellyfish, gracefully exhibit a more advanced, well-coordinated tissue-level organisation. Their bodies show a distinct structural shift with a singular central opening that effectively serves both for active food intake and immediate waste elimination.
- (b) The crucial evolutionary advantage of cnidarians lies directly in their successful development of specialised cells, specifically flexible tentacles equipped with potent stinging capabilities. These highly specialised structures allow cnidarians to actively capture passing prey and defend themselves aggressively.

reproductive efficiency. Furthermore, unlike primitive gymnosperms, angiosperms protectively develop their delicate seeds completely securely enclosed within highly nutrient-rich, structurally diverse fruits aiding widespread dispersal.

115. Draw the hierarchical pyramid of classification levels using the example of a tiger. What happens to the number of common features as we move down this pyramid?

Ans :



As we systematically move down the hierarchical pyramid of classification clearly from the incredibly broad Kingdom level directly toward the highly specific Species level, the overall number of shared common features among the grouped organisms drastically and predictably increases. At the broad Kingdom level, a truly massive variety of organisms share only a few incredibly fundamental biological traits. However, as we continually descend through much smaller groups like family and genus, the organisms exhibit vastly more incredibly specific, deeply fundamental morphological, anatomical, and genetic similarities.

116. Explain the incredibly vital role of geological fossils as essential natural records in deeply understanding the long-term evolution of global biodiversity.

Ans :

Scientists rely heavily and constantly on fossils as absolutely essential natural records because they predictably provide the absolute only direct, truly tangible physical evidence of incredibly ancient life forms that previously existed on Earth. By systematically and carefully examining the safely preserved remains found sequentially in various distinct geological rock layers, scientists

can clearly logically trace exactly how biological diversity has continuously structurally changed over millions of years. Deeply older rock layers generally predictably contain structurally incredibly simpler organisms, clearly documenting major gradual evolutionary transitions perfectly.

117. What is the modern three-domain system of biological classification? On what fundamental scientific basis did Carl Woese originally propose it?

Ans :

The three-domain system is an incredibly modern, extremely high-level biological classification framework that systematically categorizes absolutely all forms of life strictly into three distinct overarching domains: Bacteria, Archaea, and Eukarya. This brilliant system logically introduces a scientific category even fundamentally broader than a standard kingdom. Carl Woese proposed this deeply revolutionary classification system originally in 1977 based entirely on advanced comparative genetic studies. By meticulously analyzing the fundamental genetic material sequences, he effectively demonstrated that microscopic prokaryotic life forms are genetically incredibly far more diverse than believed.

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118. State any two severe human activities that are currently directly threatening global biodiversity. How exactly does the disappearance of one specific species deeply affect others?

Ans :

Global natural biodiversity is currently continuously facing absolutely severe critical threats primarily due to incredibly aggressive human activities such as rampant rapid deforestation, which totally destroys vital natural habitats, and severe environmental chemical pollution. The sudden tragic disappearance of a single keystone species can constantly have incredibly devastating cascading negative effects systematically throughout an entire fragile ecosystem. Because living organisms are intricately fundamentally interconnected within highly complex ecological food webs, the extinction of a primary plant producer consistently leads to the rapid decline of many species.

universally defining functional feature of all modern arthropods is their incredibly rigid external skeleton, commonly known scientifically as an exoskeleton.

- (b) This remarkably tough outer covering provides a massive, unparalleled evolutionary advantage; it efficiently offers robust physical protection against aggressive predators, significantly reduces vital internal water loss in exceptionally dry terrestrial environments, and brilliantly supports highly coordinated, swift bodily movements. This advanced structural design heavily contrasts with the simple organisms found in the phylum Mollusca, such as garden snails and ocean octopuses. Molluscs fundamentally possess unsegmented, notably soft internal bodies that completely lack this intricate, highly adaptable jointed armour, often restricting their overall environmental adaptability.

- 131.** (a) What exactly is a notochord, and how does its distinct anatomical presence or absence help scientists fundamentally classify complex animals?
- (b) Briefly explain the crucial evolutionary transition from simple invertebrates to advanced vertebrates by specifically referencing the unique structural role of protochordates?

Ans :

- (a) A notochord is a remarkably flexible, long, rod-shaped internal structural support system securely present in an animal's developing body during at least one vital stage of its early life. Scientists fundamentally and precisely classify the diverse animal kingdom into two major overarching groups directly based on this feature: non-chordates, which entirely lack a structural notochord, and chordates, which definitively possess it.
- (b) Protochordates act as a truly vital evolutionary biological bridge firmly connecting simpler invertebrates and highly advanced true vertebrates. They clearly exhibit a somewhat primitive, basic notochord that securely offers necessary internal structural support without severely restricting their physical aquatic movement. As biological evolution rapidly progressed over countless generations, this rudimentary notochord was ultimately replaced by a highly developed, incredibly

strong vertebral column or backbone in all true modern vertebrates, successfully allowing them to physically grow significantly larger and develop complex organs.

- 132.** (a) A biological researcher continuously observes two distinctly eukaryotic organisms under a powerful microscope; one is a rapid, single-celled organism darting in pond water, and the other is a static, multicellular organism growing extensively on decaying bread. Accurately identify their respective biological kingdoms?
- (b) Clearly outline the key structural characteristics justifying this placement?

Ans :

- (a) The highly active, single-celled organism rapidly moving in the pond water firmly belongs to the Kingdom Protista, whereas the fuzzy, static multicellular organism growing extensively on the decaying bread belongs distinctly to the Kingdom Fungi.
- (b) Protists are primarily simple unicellular eukaryotes that constantly thrive in aquatic or exceptionally moist natural environments. They definitely possess membrane-bound nuclei and frequently exhibit rapid directional movement using highly specialised microscopic structures like beating cilia or whipping flagella. On the other distinct hand, the growing organism on the old bread is a typical fungus. Fungi are predominantly complex multicellular, strictly heterotrophic eukaryotes uniquely characterised by a distinct, highly rigid cellular wall fully composed of exceptionally tough chitin rather than simple plant cellulose. They completely lack any green chlorophyll, meaning they absolutely cannot perform basic photosynthesis, and instead must obtain their essential nutrients strictly through a destructive saprophytic mode.

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CASE BASED QUESTIONS

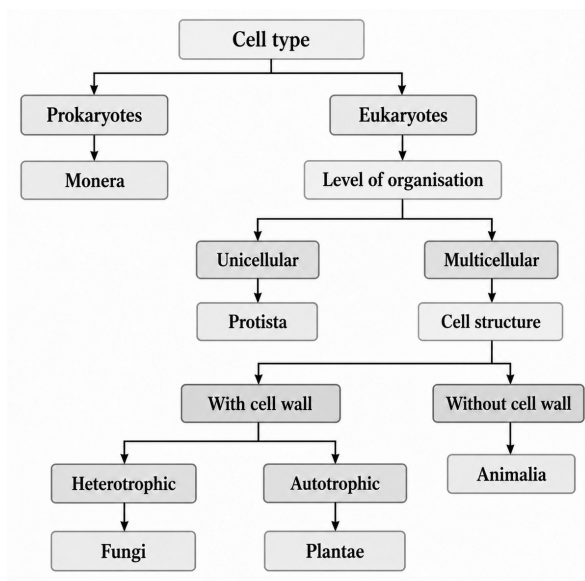
- 133.** During a summer camp, a group of students visited the Western Ghats. Their guide pointed out a unique monkey with a silver-white mane called the Lion-tailed macaque. Later, they saw beautiful blue Neelakurinji flowers blooming on the hills. The guide explained that these specific plants and animals cannot be found naturally

LONG ANSWER QUESTIONS

123. (a) Draw a flowchart illustrating the hierarchical division of the Five Kingdom classification based on cell type and body organisation?
 (b) Explain the fundamental criteria Whittaker used to differentiate these kingdoms?
 (c) Why were fungi eventually placed in a completely separate kingdom from plants?

Ans :

(a)



- (b) Robert Whittaker proposed the five-kingdom classification system based on specific fundamental characteristics. He primarily considered the basic cell structure, determining whether organisms are primitive prokaryotic or advanced eukaryotic. He also evaluated the level of body organisation, classifying organisms as either simple unicellular or complex multicellular. Additionally, the mode of nutrition played a vital role, distinguishing between autotrophs that make their own food and heterotrophs that consume others.
 (c) Fungi were originally grouped with plants but were later separated because they completely lack chlorophyll and cannot perform photosynthesis. Instead, they have a heterotrophic, saprophytic mode of nutrition, selectively absorbing vital nutrients from dead or decaying organic matter. Moreover, unlike the typical cellulose-based cell walls found in true plants, fungi possess rigid cell

walls composed primarily of a tough, complex substance called chitin, solidly justifying their placement in a distinct kingdom.

124. (a) How did the biological classification systems evolve from Aristotle's initial ideas to Whittaker's widely accepted model?
 (b) What exactly is binomial nomenclature?
 (c) Explain why the scientific community felt an absolute need to introduce this universal naming system for organisms?

Ans :

- (a) Aristotle initially grouped animals based on their basic habitat, classifying them loosely into land, water, and air dwellers. Later, Carolus Linnaeus systematically introduced the two-kingdom system comprising Plantae and Animalia. However, as advanced microscopic techniques progressively improved, scientists realised this specific system was inadequate because it awkwardly placed highly diverse microscopic organisms together. This confusion logically led to subsequent crucial revisions by Ernst Haeckel, Herbert Copeland, and finally Robert Whittaker, who effectively proposed the five-kingdom system to better represent cellular complexity and nutritional modes accurately.
 (b) Alongside structural classification, Linnaeus also introduced binomial nomenclature, which is a strictly standardised system for comprehensively naming organisms using a distinct two-part Latinised name consisting of the genus and species.
 (c) This universal naming system was practically introduced to eliminate the widespread, intense confusion constantly caused by highly variable local and regional common names.

125. (a) What do you understand by the terms endemic species and biodiversity hotspots?
 (b) Explain with suitable examples from the Indian subcontinent how expanding human activities and accelerating climate change actively threaten these incredibly fragile natural ecosystems?

Ans :

- (a) Endemic species are distinctly unique organisms naturally restricted to a very specific geographic region and absolutely not found naturally anywhere else in the world, such as

- (e) Predict what would happen to the environment if the organisms belonging to the kingdom found in the biogas plant were completely eliminated.

Ans :

- They belong to the Kingdom Monera.
- They are prokaryotes, meaning they possess a primitive nucleus without a bounding membrane.
- They belong to the Kingdom Protista.
- The organisms in the biogas plant (Monera) are prokaryotes lacking a membrane-bound true nucleus, while the ones in the stagnant water (Protista) are eukaryotes with a distinct, membrane-bound nucleus.
- Organisms in Kingdom Monera include essential decomposers and nutrient cyclers. Without them, dead organic matter and waste would not decay, nutrients would not return to the soil, and vital biogeochemical cycles would halt, eventually destroying the ecosystem.

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- 136.** While walking through a dense, moist forest, Arjun noticed shelf-like structures growing on a decaying, fallen tree trunk. They lacked green pigment and felt slightly spongy. Further down the trail, he saw strange, crusty greenish-grey patches tightly attached to the surface of large rocks. A forest ranger explained that the patches on the rocks were highly sensitive to air pollution and were actually a unique partnership between two different organisms living together for mutual benefit. The shelf-like structures on the log, however, were busy breaking down the dead wood.

QUESTIONS:

- Which kingdom do the shelf-like structures on the decaying tree trunk belong to?
- What is the specific mode of nutrition of the organisms breaking down the dead wood?
- Name the crusty greenish-grey patches on the rocks and identify the two types of organisms involved in this mutual partnership.
- Justify the forest ranger's claim that the patches on the rocks are natural indicators of environmental health.

Ans :

- They belong to the Kingdom Fungi.
- They have a heterotrophic, specifically saprophytic, mode of nutrition. They absorb nutrients from dead and decaying organic matter.
- These patches are called lichens. They are a symbiotic association between an autotrophic alga and a heterotrophic fungus.
- Lichens are highly sensitive to air pollutants. They change color or completely fail to grow in areas with high air pollution. Therefore, their healthy presence indicates clean air, making them excellent natural bioindicators for measuring environmental quality.

- 137.** A landscaping team was designing a shaded greenhouse. In the dampest, lowest corners, they planted thick green mats of mosses that hugged the wet soil closely. In slightly brighter areas, they planted tall ferns with beautifully divided leaves. The gardener noted that while the mosses stayed very short because they lacked a proper internal transport system, the ferns could grow much taller as they possessed specialised tubes to carry water from their true roots to their leaves. However, both plant types needed constant moisture in the greenhouse to successfully reproduce.

QUESTIONS:

- What descriptive title is given to mosses due to their reliance on water for reproduction despite living on land?
- What specific specialised tissues allow the ferns to grow taller than the mosses?
- Compare the body structure of the mosses with that of the ferns as described in the scenario.

Ans :

- They are called the amphibians of the plant kingdom.
- Ferns possess specialised vascular tissues, namely xylem and phloem, which efficiently transport water and food throughout the plant.
- Mosses (bryophytes) have simple root-like, stem-like, and leaf-like structures but lack true roots, stems, leaves, and vascular tissues. Ferns (pteridophytes) possess true roots, stems, and leaves, along with a well-developed vascular transport system.

- 138.** During a winter vacation in Shimla, Kabir collected woody cones from tall trees with needle-like leaves. The seeds were completely exposed on the hard flaps of the cones. Later, in his hometown in the plains, he observed a mango tree bursting with yellowish flowers that soon turned into fleshy fruits. When he cut open a ripe mango, he found a large seed safely enclosed deep inside the fruit. Kabir wondered how the harsh, dry, snowy environment of Shimla influenced the structure of the tall cone-bearing trees compared to the flowering trees in his warm hometown.

QUESTIONS:

- Which major plant group do the tall trees with woody cones and needle-like leaves belong to?
- How does the needle-like leaf structure help the cone-bearing trees survive in cold and dry regions?
- To which plant group does the mango tree belong, and what is its most defining reproductive feature?
- Compare the seed placement in the two types of trees Kabir observed.

Ans :

- They belong to the Gymnosperms.
- The needle-like leaves reduce water loss from the plant, helping it withstand the harsh, dry, and cold conditions typical of such environments.
- The mango tree belongs to the Angiosperms. Its defining reproductive feature is that it produces flowers for reproduction, and its seeds are enclosed within protective fruits.
- In the trees Kabir saw in Shimla (gymnosperms), the seeds are naked and exposed directly on the cones. In the mango tree (angiosperms), the seed is covered and safely enclosed within the fruit.

- 139.** After a heavy monsoon rain, Sarah explored her kitchen garden. She dug the moist soil and found a long, cylindrical, reddish-brown creature. Its body was divided into many little rings from head to tail, and it moved by stretching and contracting. Sitting on a nearby cabbage leaf was a completely different creature. It had a hard outer shell, a body divided into distinct sections, and three pairs of jointed legs. When Sarah accidentally touched the leaf, the hard-shelled creature quickly crawled away using its specialized legs, while the

long creature continued slowly burrowing into the soil.

QUESTIONS:

- Identify the phylum of the long, cylindrical creature found in the soil.
- What structural feature allows the creature on the cabbage leaf to move quickly?
- Identify the phylum of the hard-shelled creature with jointed legs.
- What is the survival advantage of the hard outer shell for the creature on the leaf?
- Compare the body segmentation of the two creatures described in the scenario.

Ans :

- It belongs to Phylum Annelida.
- It has jointed legs or appendages which allow for quick, controlled, and complex movements.
- It belongs to Phylum Arthropoda.
- The hard outer shell acts as an exoskeleton that provides protection, reduces water loss, and supports powerful muscles for movement in dry and exposed environments.
- The annelid (earthworm) has a cylindrical body divided into many similar, repeating ring-like segments that aid in basic flexibility. The arthropod (insect) also has a segmented body, but its segments are highly modified and grouped into distinct functional regions.

- 140.** A university research team discovered a new species of large cat in a remote tropical rainforest. The local indigenous tribe called the animal Kala Bagh in their native dialect. However, a visiting French scientist called it Tigre Noir. To prevent global confusion when publishing their findings, the research team decided to assign the animal a two-part scientific name. They noticed it shared a similar skull structure and roaring ability with lions and tigers, so they officially named it *Panthera obscura* following the internationally accepted naming rules.

QUESTIONS:

- What is the system of assigning a two-part scientific name to an organism called, and who introduced it?
- In the name *Panthera obscura*, what taxonomic levels do the first and second words represent respectively?
- Explain why the researchers chose *Panthera* as the first part of the newly discovered animal's name.

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Ans :

- (a) It is called the Binomial system of nomenclature, introduced by Carolus Linnaeus in the 18th century.
- (b) The first word (Panthera) represents the genus, and the second word (obscura) represents the species.
- (c) The researchers chose Panthera because the new animal shares common evolutionary features, such as skull structure and the ability to roar, with closely related species like lions and tigers that already belong to the genus Panthera.
141. In a natural history museum, a large chart on the wall shows the classification of a domestic dog and a grey wolf. The chart illustrates that both animals belong to the Kingdom Animalia, Phylum Chordata, Class Mammalia, Order Carnivora, Family Canidae, and Genus Canis. However, the dog is listed as *Canis familiaris*, while the wolf is listed as *Canis lupus*. A teacher explains to her students that as you move down the chart from the top kingdom level to the bottom, the animals share more and more specific features, acting almost like a postal address pointing to a specific house.

QUESTIONS:

- (a) Based on the chart, are dogs and wolves members of the exact same species? Give a reason from the text.
- (b) Which taxonomic category is broader and includes more diverse organisms: Phylum Chordata or Family Canidae?
- (c) What fundamental physical structure dictates the placement of an animal in the Phylum Chordata?
- (d) Why does the teacher compare biological classification to a postal address?

Ans :

- (a) No, they are not members of the same species. The text states the dog is *familiaris* and the wolf is *lupus*, which indicates they belong to different species under the same genus.
- (b) Phylum Chordata is broader. As you move higher up the hierarchy, the groups become larger and include a much wider diversity of organisms compared to the lower category of Family Canidae.

- (c) Placement in the Phylum Chordata is based on the presence of a notochord, which is a flexible rod-shaped structure, at some stage during their life.
- (d) Just as a postal address moves from a broad area like a country to a highly specific location like a house number, classification starts with broad groups like a kingdom and narrows down step-by-step to specific organisms at the species level, helping scientists locate and identify them precisely.

142. Lake Loktak in Manipur is famous for its phumdis, which are thick, floating mats of soil and vegetation. These unique floating islands are the only natural home to the Sangai, a rare species of deer with specially adapted hooves that prevent it from sinking into the spongy ground. Recently, environmentalists reported that agricultural runoff and the construction of local dams have altered the lake's water levels, causing the phumdis to thin out and break apart. The deer population is rapidly declining as their sole habitat disappears, prompting emergency conservation measures by the government.

QUESTIONS:

- (a) What specific term describes the Sangai deer because it is naturally found only on the phumdis of Manipur and nowhere else?
- (b) How have the Sangai deer structurally adapted to survive on their unique floating habitat?
- (c) Identify the main human activities threatening the biodiversity of Lake Loktak mentioned in the scenario.
- (d) Why are the phumdis essential for the survival of the Sangai deer?
- (e) If the Sangai deer becomes extinct, how might this event affect the broader ecological balance?

Ans :

- (a) The Sangai deer is an endemic species.
- (b) They have specially adapted hooves and elongated patterns that prevent them from sinking into the soft, spongy, floating vegetation of the phumdis.
- (c) Agricultural runoff and the construction of local dams are the main human activities threatening the lake's habitat.

5. How are mountain and valley breezes formed? Suppose there are two mountains, one covered with grass and another covered with barren rocks; would the temperature of the two mountain breezes be different? If so, how?

Ans :

Mountain and valley breezes are local winds formed by the uneven heating of terrain. During the day, mountain slopes heat up faster than the valley floor, causing the air above them to warm, rise, and be replaced by cooler air from the valley, forming a valley breeze. At night, the slopes lose heat faster and become cooler than the valley; the denser, cold air then flows down into the valley as a mountain breeze.

If one mountain is covered with grass and the other with barren rocks, the temperature of their mountain breezes would be different. Barren rocks have a lower specific heat capacity and lack vegetation to regulate temperature, meaning they cool down much more rapidly at night than a grass-covered slope. Therefore, the mountain breeze descending from the barren rock mountain would be noticeably colder and denser than the breeze from the grass-covered mountain.

6. You have witnessed weather phenomena, such as winds, storms, rainfall, etc. Which atmospheric layer is mainly responsible for such phenomena and what is the primary reason for its occurrence?

Ans :

The troposphere is the atmospheric layer mainly responsible for weather phenomena such as winds, storms, and rainfall. The primary reason for these occurrences is the uneven heating of the Earth's surface by solar radiation. This uneven heating causes variations in air pressure, driving the movement of warm air rising and cold air sinking, which, combined with the fact that temperature decreases with height in the troposphere, creates dynamic weather systems.

7. Explain the processes involved in the nitrogen cycle. How would life on Earth be affected if nitrogen were not cycled?

Ans :

The nitrogen cycle involves several key processes: nitrogen fixation (conversion of atmospheric nitrogen into ammonia by soil bacteria or lightning), nitrification (conversion of ammonia to nitrites and then nitrates by nitrifying bacteria),

assimilation (plants absorbing nitrates from soil and animals consuming plants), ammonification (decomposers breaking down dead organic matter to release ammonia), and denitrification (denitrifying bacteria converting nitrates back into nitrogen gas).

If nitrogen were not cycled, life on Earth would eventually cease. Nitrogen is an essential building block for proteins and nucleic acids (like DNA) in all living organisms; without a replenished supply of usable nitrogen compounds in the soil, plant growth would stop, leading to the collapse of entire food webs.

8. What are the impacts of deforestation on the Earth's oxygen and carbon cycles? What are the other consequences of deforestation?

Ans :

Deforestation severely impacts the carbon cycle by removing trees that act as natural carbon sinks, meaning less carbon dioxide is absorbed through photosynthesis, which leads to a buildup of greenhouse gases in the atmosphere. It impacts the oxygen cycle because fewer plants are available to release oxygen back into the air.

Other consequences of deforestation include decreased plant transpiration leading to a decline in local rainfall, increased soil erosion because there are fewer roots to hold the topsoil, and massive habitat destruction resulting in a significant decline in biodiversity.

9. Explain with suitable diagram the path that carbon takes to go back to the atmosphere. You may start from plants using CO₂ from the atmosphere.

Ans :

Carbon returns to the atmosphere through several pathways after being absorbed. Plants use atmospheric CO₂ for photosynthesis to make glucose. When plants, and the animals that consume them, undergo respiration, they break down this glucose for energy and release CO₂ back into the atmosphere. Additionally, when these organisms die, decomposers break down their organic matter, releasing CO₂ during decomposition. Over millions of years, buried dead matter forms fossil fuels; when humans extract and burn these fuels (combustion) for energy, large amounts of stored carbon are rapidly released back into the atmosphere as CO₂.

CHAPTER 13

Earth as a System: Energy, Matter, and Life

SUMMARY

1. EARTH AS A SYSTEM: ENERGY, MATTER, AND LIFE

Life on Earth depends on the continuous flow of energy and matter. The Sun is the main energy source. The Earth consists of interacting spheres—geosphere, hydrosphere, cryosphere, atmosphere, and biosphere. Changes in one sphere affect others, leading to environmental impacts like floods, droughts, and habitat loss.

1.1 Uneven Heating of the Earth

Solar radiation is unevenly distributed due to Earth's shape and tilt. Different surfaces absorb heat differently, and albedo determines how much radiation is reflected. This uneven heating drives winds, ocean currents, and seasonal variations.

1.2 Interaction of solar radiation on the Earth's surface

Different materials heat differently under sunlight. Dark surfaces absorb more heat, while light surfaces reflect more. High albedo regions like snow remain cooler, whereas urban areas absorb heat, causing the Urban Heat Island effect..

1.3 Latitude and Earth's shape

Solar rays are more concentrated near the equator and spread out near the poles. This causes temperature differences and contributes to seasons, winds, and ocean circulation..

1.4 Role of the atmosphere

The atmosphere regulates temperature, absorbs harmful radiation, and supports life. Greenhouse gases keep Earth warm, but excess gases cause global warming. The ozone layer protects against UV radiation, and its depletion harms ecosystems.

2. UNEVEN HEATING CAUSES WIND AND OCEAN CURRENTS

Pressure differences due to uneven heating cause winds. These include local winds, planetary winds, and ocean currents, which help distribute heat and maintain climate balance.

2.1 Local winds

Local winds like valley and mountain breezes are caused by temperature differences between slopes and valleys. They influence local climate and agriculture.

2.2 Planetary winds

Global wind systems form due to pressure belts between the equator and poles. Earth's rotation causes wind deflection, creating large-scale circulation patterns.

2.3 Ocean currents

Ocean currents are driven by winds, temperature, salinity, and Earth's rotation. They regulate climate and transport nutrients, supporting marine ecosystems.

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3. BIOGEOCHEMICAL CYCLES

These cycles involve the movement of matter and energy between living and non-living components, ensuring the recycling of essential elements.

3.1 Water cycle

Water moves through evaporation, transpiration, condensation, precipitation, and groundwater flow. Climate change is intensifying this cycle, causing floods, droughts, and reduced groundwater recharge.

15. Describe the interrelationship between different spheres of the Earth. Illustrate with example how these spheres function in a delicate balance.

Ans :

The Earth's spheres—geosphere, hydrosphere, cryosphere, atmosphere, and biosphere—are interconnected systems that constantly exchange matter and energy. A disturbance in one sphere inevitably ripples through the others. For example, if human activities (biosphere) release excessive carbon dioxide into the air (atmosphere), it enhances the greenhouse effect and raises global temperatures. This warming causes glaciers to melt (cryosphere), which adds water to the oceans and raises sea levels (hydrosphere). The rising seas can then erode coastlines (geosphere) and flood coastal habitats, threatening the survival of terrestrial and marine life (biosphere), illustrating how closely dependent these spheres are on a delicate balance.

OBJECTIVE QUESTIONS

1. According to the foundational scientific text, what artificial industrial process entirely revolutionized global agriculture and effectively provides the complex nitrogen atoms found abundantly in more than half of the human body today?
- (A) The Montreal Protocol
(B) The Haber-Bosch process
(C) The Keeling curve
(D) The Kyoto Protocol

Ans : (B)

The Haber-Bosch process, developed in the early twentieth century, artificially fixes atmospheric nitrogen to efficiently produce ammonia for synthetic fertilisers. This massive industrial breakthrough successfully revolutionized global agriculture by feeding billions of people. Consequently, more than half of the complex nitrogen atoms present in human bodies today originate from this process.

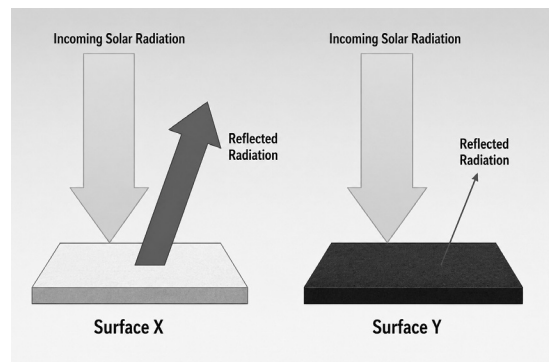
2. Why do urban areas generally experience higher temperatures than surrounding rural areas during hot summer nights?
- (A) Rural areas contain dense forests that actively release massive amounts of carbon dioxide.
(B) Buildings and asphalt absorb solar radiation during the day and re-radiate it at night.

- (C) Urban centers are completely devoid of any atmospheric greenhouse gases.
(D) The high albedo of concrete completely reflects all thermal heat upwards.

Ans : (B)

Urban areas are mostly built with materials like concrete, steel, and asphalt, which absorb large amounts of solar radiation during the day. This trapped heat is then re-radiated into the environment during the night, keeping cities significantly warmer than rural areas. This phenomenon is commonly called the urban heat island effect.

Based on the provided diagram comparing two different Earth surfaces, which conclusion about energy interaction is most accurate?



- (A) Surface X absorbs more radiation and represents the ocean.
(B) Surface X reflects more radiation and represents a polar ice cap.
(C) Surface Y has a higher albedo and represents a dark asphalt road.
(D) Surface Y retains less heat energy and represents a dense forest.

Ans : (B)

Surface X reflects the majority of incoming solar radiation, exhibiting a high albedo characteristic of snow or polar ice caps. Surface Y absorbs most light, typical of low-albedo surfaces like oceans. This visual representation demonstrates how material properties dictate heat retention, driving the uneven heating of the planetary surface.

4. What is the approximate numerical value of the solar constant situated at the top of the Earth's atmosphere?
- (A) 14.4 kilowatts per square metre
(B) 1.4 kilowatts per square metre

source for most terrestrial and marine organisms. Similarly, a halted nitrogen cycle would mean organisms could no longer access soluble nitrogen to synthesize vital proteins, ultimately leading to the collapse of all ecosystems and the extinction of plants and animals.

6. Discuss how human activities increase the concentration of greenhouse gases in the atmosphere. What would you do as an individual to reduce the emission of greenhouse gas?

Ans :

Human activities drastically increase greenhouse gas concentrations primarily through the extensive burning of fossil fuels for electricity and transportation, which releases massive amounts of carbon dioxide into the air. Furthermore, large-scale deforestation removes the trees that naturally absorb this excess carbon dioxide, thereby saturating natural carbon sinks and intensifying the greenhouse effect. As an individual, I would actively reduce emissions by adopting eco-friendly habits like conserving electricity, minimizing waste by reusing and recycling materials, and participating in tree-planting initiatives to help restore environmental balance.

NCERT EXERCISE

- Choose the most appropriate option to describe the role of biogeochemical cycles in an ecosystem.
 - To provide food directly to all organisms.
 - To recycle essential nutrients between biotic and abiotic components.
 - To create new elements for use by living things.
 - To remove pollutants and toxins from the organism.

Ans :

Option (ii) is correct. Biogeochemical cycles ensure the continuous cyclic movement and recycling of essential matter and nutrients (like carbon, nitrogen, and oxygen) between the non-living (abiotic) and living (biotic) components of the Earth, keeping them available to support life.

- Which of the following is primarily responsible for warming of the Earth?
 - Solar radiation is immediately absorbed by carbon dioxide, which then releases it as heat.

- The atmosphere's tiny particles absorb incoming solar radiation, which directly heats the Earth.
- The Earth's surface absorbs solar radiation, which is then re-radiated and trapped by greenhouse gases.
- The Earth's environment is heated only by the solar radiation reflected by the clouds.

Ans :

Option (iii) is correct. The Earth's surface primarily absorbs visible light from the Sun and re-radiates it as infrared radiation (heat), which is then absorbed and trapped by greenhouse gases in the atmosphere, keeping the Earth warm.

- Explain how climate change affects the water cycle. Illustrate with examples.

Ans :

Climate change significantly impacts the water cycle by altering temperature and moisture patterns, as a warmer atmosphere can hold more moisture. This leads to heavier rains in some areas and severe droughts in others. For example, intensified monsoons can cause sudden bursts of intense rainfall that increase runoff, erode soil, and reduce groundwater recharge. Additionally, global warming causes glaciers to melt, adding more water to rivers and oceans, which raises sea levels and threatens coastal cities like Mumbai and Chennai.

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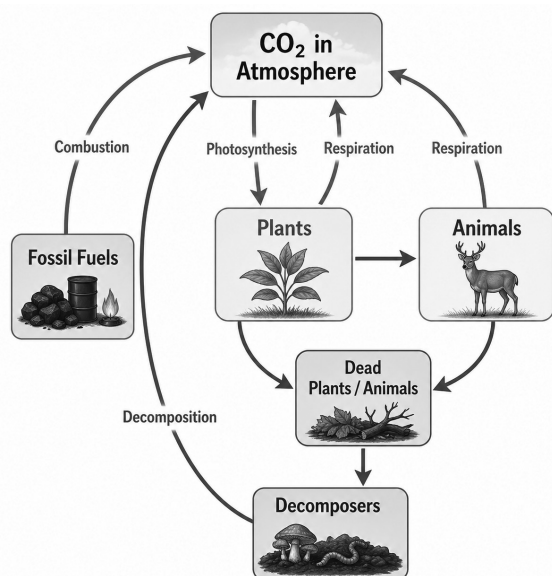
- Describe how albedo affects the Earth's surface temperature and its climate.

Ans :

Albedo is the fraction of solar radiation reflected by a surface. Surfaces with high albedo, such as snow and ice, reflect a large proportion of incoming sunlight and absorb very little, which helps keep polar regions very cold. Conversely, surfaces with low albedo, like dark soil or ocean water, reflect less light and absorb more solar radiation, causing them to heat up more quickly and remain relatively warmer. The distribution of these different surfaces dictates regional heat absorption, thereby heavily influencing the Earth's overall climate and temperature patterns.

- (d) The phumdis are essential because they are the only natural habitat for the Sangai deer, providing them with necessary food and a specific environment suited to their physical adaptations.
- (e) Every species plays a specific role in nature. The extinction of the Sangai deer would remove a primary consumer from that specific food web, potentially causing overgrowth of certain vegetation, depriving natural predators of food, and ultimately destabilising the fragile local ecosystem.

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10. Why is an excess of CO_2 in the atmosphere considered undesirable even though it is required by plants?

Ans :

An excess of CO_2 in the atmosphere is undesirable because it acts as a potent greenhouse gas. While plants require it for photosynthesis, excessive amounts of CO_2 trap too much of the infrared heat re-radiated by the Earth's surface, intensifying the greenhouse effect. This unchecked trapping of heat leads to global warming, which causes severe environmental issues such as the melting of polar ice, rising sea levels, extreme weather events, and ocean acidification.

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11. How is heat lost from the surface of the Earth? What is its significance?

Ans :

Heat is lost from the surface of the Earth when the solar energy absorbed by the ground and oceans is re-radiated back upward into the atmosphere and eventually into space in the form of infrared radiation. The significance of this heat loss is that it maintains the Earth's energy balance. Without radiating heat back out, the Earth would continuously accumulate solar energy and become too hot to support life; the balance between incoming solar radiation and outgoing infrared heat creates a stable climate.

12. If the Earth were a flat disc instead of a sphere, how would the patterns of solar radiation and temperature be different?

Ans :

If the Earth were a flat disc facing the Sun, solar radiation would strike the entire surface at the same direct angle, meaning solar energy (insolation) would be distributed evenly across the disc. Consequently, there would be no uneven heating caused by latitude; the temperature would be generally uniform everywhere, completely eliminating the distinct climate zones (like tropical, temperate, and polar) and large-scale planetary wind systems that exist on our spherical Earth.

13. Suppose there is a rise in atmospheric temperature on Earth. How would this affect the cryosphere, hydrosphere and biosphere?

Ans :

A rise in atmospheric temperature would cause accelerated melting of snow, glaciers, and polar ice caps in the cryosphere. This melting would transfer massive amounts of water into the hydrosphere, leading to rising sea levels, flooding of low-lying areas, and warmer ocean temperatures. These changes would disrupt the biosphere by causing widespread habitat loss, threatening coastal ecosystems like mangroves, damaging coral reefs due to warmer and more acidic waters, and altering weather patterns that affect global agriculture and food supply.

14. Explain how the Earth's atmosphere helps in maintaining a suitable temperature for life to survive on the Earth.

Ans :

The Earth's atmosphere maintains a suitable temperature primarily through the greenhouse effect. While the atmosphere lets visible sunlight pass through to warm the Earth's surface, greenhouse gases (like carbon dioxide, methane, and water vapour) absorb and trap a portion of the infrared heat that the surface re-radiates back upwards. This trapped heat acts like an insulating blanket, keeping the Earth comfortably warm and preventing the drastic, freezing temperature drops that would occur at night without an atmosphere.

3.2 Carbon cycle

Carbon circulates between atmosphere, oceans, and living organisms. Human activities like burning fossil fuels increase carbon dioxide, leading to global warming.

3.3 Nitrogen cycle

Nitrogen is converted into usable forms through fixation, nitrification, assimilation, ammonification, and denitrification. Excess fertiliser use disrupts this cycle.

3.4 Oxygen cycle

Oxygen is used in respiration and released in photosynthesis. It maintains balance between living organisms and the environment.

4. HUMAN IMPACT ON EARTH'S PROCESSES

Human activities disrupt natural cycles, causing pollution, climate change, eutrophication, and ecosystem imbalance. Sustainable practices and global efforts are essential to restore environmental balance.

PAUSE AND PONDER

1. Visit the website given below and study the effect of the concentration of greenhouse gas on surface temperature, <https://phet.colorado.edu/en/simulations/greenhouse-effect>

Ans :

Studying the simulation reveals that an increase in the concentration of greenhouse gases, such as carbon dioxide and methane, enhances the greenhouse effect by trapping more outgoing infrared heat. This prevents the re-radiated heat from escaping into space. Consequently, this leads to a steady increase in the Earth's average surface temperature, which drives global warming.

2. How does the cool mountain breeze benefit agriculture activity, particularly the crops and soil?

Ans :

The cool mountain breeze that flows down into the valleys helps regulate the local temperature, preventing the environment from becoming

excessively warm during the night. This natural circulation helps maintain favorable moisture conditions, which is crucial for preventing the soil from drying out rapidly. Ultimately, these stable temperature and moisture levels support overall crop health and sustain fruitful agricultural activities in mountainous regions.

3. What happens to the warm surface of water from the equator as it travels toward the poles? What impact does this movement have on the area?

Ans :

As warm surface water travels from the equator toward the poles, it transports significant amounts of heat, and upon cooling, it becomes denser and sinks to flow back toward the equator. This continuous movement helps to significantly reduce extreme temperature differences across the planet. The impact on the regions it flows towards is a moderating influence on the local climate, such as keeping high-latitude coastal areas and ports relatively warm and ice-free during harsh winters.

4. The CO₂ dissolved in the ocean is disturbed when the global temperature increases. What will happen to marine life?

Ans :

As global temperatures rise, warmer ocean waters lose their capacity to act as an effective carbon sink, while excess atmospheric carbon dioxide increases seawater acidity. This heightened acidity directly threatens the survival of tiny plankton and coral reefs by affecting their ability to form shells. Ultimately, the disturbance of these foundational species would cause severe habitat loss and severely disrupt the entire marine ecosystem.

5. What would happen to plants and animals on Earth if the biogeochemical cycles were disrupted and stopped? Explain by giving a few examples.

Ans :

If biogeochemical cycles were completely stopped, the continuous recycling of essential matter and energy between the living and non-living components of Earth would cease, leading to a rapid depletion of life-sustaining nutrients. For example, without the carbon cycle, plants would eventually run out of atmospheric carbon dioxide necessary for photosynthesis, eliminating the primary food

- (C) 3.6 kilowatts per square metre
(D) 100 kilowatts per square metre

Ans : (B)

The solar constant represents the average amount of solar energy received per unit time per unit area perpendicular to the Sun's rays at the top of the atmosphere. Its value is approximately 1.4 kilowatts per square metre, or about fourteen hundred joules per second per square metre before atmospheric absorption.

5. Match the specific biological processes of the nitrogen cycle with their correct scientific descriptions:

	List-I (Process)		List-II (Description)
P.	Nitrogen fixation	1.	Conversion of atmospheric nitrogen into ammonia
Q.	Ammonification	2.	Conversion of ammonia into nitrites and then nitrates
R.	Nitrification	3.	Conversion of organic matter into ammonia by decomposers
S.	Denitrification	4.	Conversion of nitrates back into nitrogen gas

- (A) P-1, Q-2, R-3, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-3, Q-1, R-4, S-2

Ans : (B)

The nitrogen cycle involves several distinct biological processes. Nitrogen fixation converts atmospheric nitrogen directly into ammonia. Ammonification breaks down dead organic matter to produce ammonia. Nitrification then transforms this ammonia into nitrites and nitrates for plant absorption. Finally, denitrification converts the soil nitrates back into atmospheric nitrogen gas, completing the cycle.

6. **Assertion (A):** The maximum insolation actively reaching the Earth's surface is exactly equal to the calculated solar constant.
Reason (R): Gases, clouds, and dust particles in the atmosphere actively absorb and scatter a significant portion of the incoming solar energy.

- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (D)

The assertion is completely false because the maximum insolation reaching the Earth's surface is always lower than the solar constant. The reason is a true statement and explains this reduction, as atmospheric components like gases, dust, and clouds absorb and scatter significant amounts of solar energy before it reaches the surface.

7. Consider the following statements regarding the distinct spheres of the Earth system:
1. The geosphere strictly includes solid rocks, soil, and landforms.
 2. The cryosphere directly includes all the oceans and underground water.
 3. The biosphere fully encompasses all living organisms and their habitats.

Which of the statements given above are correct?

- (A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 1, 2, and 3

Ans : (C)

The geosphere correctly represents the solid parts of the Earth, including landforms like mountains and plateaus. The biosphere encompasses all living organisms and their habitats. However, the cryosphere represents the solid form of water, such as ice and snow, whereas oceans and underground water are components of the hydrosphere.

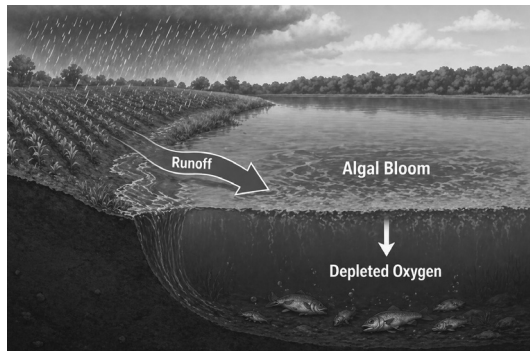
8. If the direct solar insolation measured on the surface of the Earth is 1 kWm^{-2} , how much total solar energy is safely received by a 2 m^2 area in precisely two hours?
- (A) $3.6 \times 10^6 \text{ J}$
(B) $7.2 \times 10^6 \text{ J}$
(C) $14.4 \times 10^6 \text{ J}$
(D) $1.4 \times 10^3 \text{ J}$

Ans : (C)

The total energy received is calculated by multiplying intensity, area, and time. Given an intensity of one kilowatt per square metre, an area of two square metres, and a time of two hours (which equals seven thousand two hundred

seconds), the energy equals fourteen point four multiplied by ten to the power of six joules.

9. The diagram models an ecological disruption in a local water body. What is the initiating factor for the chain of events shown?



- (A) The accumulation of industrial heavy metals toxic to aquatic plant life.
 (B) An excessive influx of nitrates and phosphates from agricultural fertilizers.
 (C) A drastic increase in the water temperature due to industrial cooling systems.
 (D) The over-harvesting of predatory fish leading to an overpopulation of algae.

Ans : (B)

The diagram illustrates eutrophication, a process triggered when agricultural runoff carries excessive fertiliser nutrients, primarily nitrates, into aquatic ecosystems. This nutrient overload stimulates rapid, unchecked algal growth. As algae die and decompose, the process consumes dissolved oxygen, creating hypoxic conditions that ultimately suffocate and kill fish populations in the ecosystem.

10. Arrange the major layers of the Earth's atmosphere strictly in ascending vertical order starting directly from the solid surface:
1. Mesosphere
 2. Troposphere
 3. Exosphere
 4. Stratosphere
 5. Thermosphere
- (A) 2, 4, 1, 5, 3
 (B) 2, 1, 4, 3, 5
 (C) 4, 2, 1, 5, 3
 (D) 2, 4, 5, 1, 3

Ans : (A)

The Earth's atmosphere has a highly structured, layered arrangement based on variations in

temperature and composition. Starting from the surface, the lowest layer is the troposphere, followed by the stratosphere which contains the ozone layer. Above these are the mesosphere, the thermosphere, and finally the outermost region known as the exosphere.

11. Read the following statements concerning the active circulation of global planetary winds:

1. Planetary winds invariably move directly from high-pressure to low-pressure regions without any deviation.
2. The rapid rotation of the Earth heavily causes moving winds to follow noticeably curved paths.
3. Flowing winds are steadily deflected towards the right throughout the Northern Hemisphere.
4. Flowing winds are steadily deflected towards the left throughout the Southern Hemisphere.

Which of the statements given above are accurate?

- (A) 1, 2, and 3
 (B) 2, 3, and 4
 (C) 1, 3, and 4
 (D) 1, 2, 3, and 4

Ans : (B)

The Earth's rotation on its axis prevents planetary winds from traveling in a straight line between pressure belts. Instead, they follow distinctly curved paths. This phenomenon deflects moving air masses towards the right in the Northern Hemisphere and towards the left in the Southern Hemisphere, heavily influencing global atmospheric circulation patterns.

12. Which specific electromagnetic wavelength range accurately corresponds to the invisible but highly energetic ultraviolet (UV) rays?
- (A) 400 nm to 700 nm
 (B) 100 nm to 400 nm
 (C) 10 nm to 100 nm
 (D) 700 nm to 1000 nm

Ans : (B)

Ultraviolet rays are a part of the electromagnetic spectrum characterized by shorter wavelengths and higher energy than visible light. They specifically fall within the wavelength range of one hundred nanometres to four hundred nanometres. Prolonged human exposure to these highly energetic rays can severely damage the eyes and the skin.

- 13. Assertion (A):** Visible weather phenomena like rain clouds and heavy storms are largely absent within the high stratosphere.

Reason (R): The air temperature slowly increases with height in the stratosphere due to strong UV absorption by ozone, completely preventing the vertical mixing of air.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The assertion is true as almost all weather is confined to the troposphere. The reason is also true and perfectly explains the assertion. The ozone layer absorbs ultraviolet radiation, causing the temperature to rise with altitude. This temperature inversion creates a highly stable atmospheric layer, entirely preventing the vertical mixing of air.

- 14.** Based on the provided table, which surface will absorb the maximum solar radiation and heat up most rapidly during the day?

Surface Material	Albedo Value
Surface W	0.85
Surface X	0.10
Surface Y	0.60
Surface Z	0.25

- (A) Surface W
 (B) Surface X
 (C) Surface Y
 (D) Surface Z

Ans : (B)

Albedo represents the fraction of solar radiation reflected by a surface. A lower albedo value means the surface reflects less light and absorbs more solar energy. Surface X has the lowest albedo at 0.10, indicating it will absorb the highest amount of incoming solar radiation, causing it to heat up the most rapidly among the given options.

- 15.** Select the correct sequential order of the given electromagnetic waves based strictly on their progressively increasing wavelength:

- (A) Radio waves, Microwaves, Infrared, Visible, Ultraviolet, X-rays, Gamma rays

- (B) Gamma rays, X-rays, Ultraviolet, Visible, Infrared, Microwaves, Radio waves
 (C) X-rays, Gamma rays, Ultraviolet, Visible, Infrared, Radio waves, Microwaves
 (D) Microwaves, Radio waves, Infrared, Visible, Ultraviolet, Gamma rays, X-rays

Ans : (B)

The electromagnetic spectrum spans a very wide range of frequencies and wavelengths. Gamma rays and X-rays have the highest frequencies and the shortest wavelengths. As we move across the spectrum through ultraviolet, visible light, and infrared, the wavelengths progressively increase, finally reaching microwaves and radio waves which possess the longest wavelengths.

How does highly saline ocean water naturally behave when it physically interacts with ocean water possessing significantly lower salinity?

- (A) The higher salinity water immediately becomes less dense and strictly remains near the upper surface.
 (B) The higher salinity water instantly evaporates, leaving a massive blanket of completely dense water behind.
 (C) The varying salinity completely loses any direct effect on the water's density or its vertical movement.
 (D) The higher salinity water becomes noticeably denser, steadily sinks, and gently moves at much deeper levels.

Ans : (D)

The concentration of dissolved salts heavily influences the density of ocean water. Water with higher salinity becomes significantly denser than surrounding lower salinity water. Because of this increased density, the highly saline water naturally sinks downward and continuously flows at much deeper levels within the global ocean circulation system.

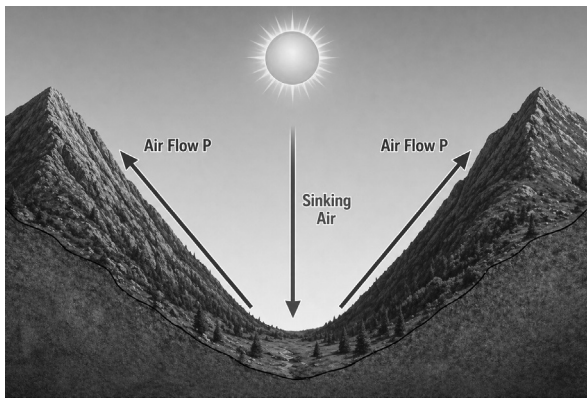
- 17.** Which of the following statements describing the daily formation of localized winds is physically INCORRECT?

- (A) Fast valley breezes actively occur during the bright day when mountain slopes heat up quite rapidly.
 (B) Slow mountain breezes actively occur at night when mountain slopes completely cool down much faster.
 (C) During a typical valley breeze, relatively cooler air from the valley steadily moves up the heated slopes.

Ans : (B)

The continuous movement of immense ocean water masses forms large circular circulation patterns known as gyres. Because of the Earth's rotation and the resulting Coriolis effect, moving water masses are deflected to the right. Consequently, these massive oceanic gyres steadily rotate in a strictly clockwise direction throughout the Northern Hemisphere.

33. The diagram illustrates a specific localized air circulation pattern in a mountainous region. Based on the thermal dynamics shown, what phenomenon is occurring?



- (A) It is nighttime, and Air Flow P represents a mountain breeze caused by rapid cooling of the slopes.
- (B) It is daytime, and Air Flow P represents a valley breeze caused by the rapid heating of the mountain slopes.
- (C) It is daytime, and Air Flow P represents a mountain breeze driven by a high-pressure zone on the slopes.
- (D) It is nighttime, and Air Flow P represents a valley breeze replacing rising warm air in the valley center.

Ans : (B)

The presence of the sun indicates daytime. During the day, mountain slopes heat up faster than the valley floor. The air immediately above the slopes warms, becomes less dense, and rises, as indicated by the upward arrows (Air Flow P). This upward movement of air originating from the valley is definitively a valley breeze. Other options misidentify the time or breeze type.

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34. If the Earth's massive gravitational pull were to somehow become significantly much weaker permanently, which of the following harsh events would most likely be the incredibly immediate and disastrous consequence heavily regarding its protective spheres?
- (A) The solid rocky geosphere would instantly and completely become entirely boiling liquid everywhere.
 - (B) The spinning Earth would highly likely completely lose its entire protective atmosphere quickly into cold outer space.
 - (C) The massive global ocean currents would completely reverse their flowing direction violently and permanently.
 - (D) The thriving entire biosphere would instantly and safely adapt to completely anaerobic deep respiration.

Ans : (B)

The atmosphere consists of a massive mixture of gases securely held tightly in place around the planet by the force of Earth's gravity. If this gravitational pull were to become significantly weaker, the vital atmospheric gases would rapidly escape into the surrounding outer space, rendering the planet completely barren and uninhabitable.

35. Why exactly do vast equatorial regions strictly remain relatively very warm completely throughout the entire year when carefully compared to the freezing cold polar regions?
- (A) The bulging equator is physically located much significantly closer directly to the hot Sun than the freezing poles.
 - (B) The Sun's intense rays powerfully fall very directly and heavily concentrate tightly over a distinctly smaller local area strictly at the equator.
 - (C) The massive equatorial oceans heavily possess a much noticeably lower specific heat entirely than the completely frozen polar oceans.
 - (D) The protective ozone layer is significantly much thicker directly at the equator, completely trapping much more internal heat.

Ans : (B)

Because the Earth is spherical, solar radiation strikes various latitudes at completely different angles. At the equator, the Sun's powerful rays strike almost perpendicularly, concentrating intense solar energy over a notably smaller surface area. Conversely, in polar regions, the incoming

- (A) 1 and 2
 (B) 2 and 3
 (C) 1 and 3
 (D) 1, 2, and 3

Ans : (B)

The slow carbon cycle strictly operates over millions of years, involving the deep burial of dead organisms to slowly form fossil fuels. Additionally, marine organisms utilize dissolved carbon dioxide to create durable shells, which eventually accumulate on the ocean floor. Photosynthesis is a rapid process belonging to the fast carbon cycle.

22. Which statement correctly identifies a characteristic of the atmospheric layers presented in the table?

Layer Designation	Altitude Range (km)	Temperature Trend with Increasing Altitude
Layer P	0–12	Decreasing
Layer Q	12–50	Increasing

- (A) Layer P contains the ozone gas that absorbs incoming ultraviolet radiation.
 (B) Layer Q hosts the major weather events due to rapid vertical air mixing.
 (C) Layer P represents the troposphere where weather forms as warm air rises.
 (D) Layer Q represents the thermosphere where temperature drops with altitude.

Ans : (C)

The table data shows temperature decreasing with altitude in Layer P (0–12 km), which is the primary characteristic of the troposphere. Nearly all weather phenomena occur within this specific layer as warm air rises from the surface. Layer Q (12–50 km) is the stratosphere, where temperature increases due to ultraviolet radiation absorption by the ozone layer.

23. Which of the following inert gases is NOT primarily classified as an active greenhouse gas within the Earth's lower atmosphere?
 (A) Carbon dioxide
 (B) Methane
 (C) Water vapour
 (D) Argon

Ans : (D)

Greenhouse gases naturally trap outgoing infrared radiation to keep the Earth warm. Carbon dioxide, methane, and water vapour are highly effective

greenhouse gases that significantly contribute to this warming effect. Argon, however, is an inert noble gas making up a small atmospheric fraction and does not exhibit any greenhouse warming properties.

24. A city planner strongly wants to noticeably reduce the devastating Urban Heat Island effect within a rapidly expanding metropolitan area. Which specific strategy would be highly effective based largely on the scientific concept of albedo?

- (A) Purposely building extremely narrow urban streets to vastly increase ground shade everywhere.
 (B) Exclusively using very dark-coloured, heavy materials for all brand new highway construction.
 (C) Actively painting massive building roofs entirely with very light-coloured, highly reflective paints.
 (D) Completely removing mature urban trees to aggressively increase rapid local wind circulation.

Ans : (C)

The concept of albedo indicates that light-coloured surfaces reflect significantly more solar radiation, while dark surfaces absorb it. By applying light-coloured, highly reflective paints to building roofs, the city can substantially increase its overall albedo. This directly reduces heat absorption, keeping buildings cooler and effectively mitigating the urban heat island effect.

25. **Assertion (A):** Unregulated large-scale massive deforestation can tragically lead to a very significant decline in crucial local rainfall.

Reason (R): Completely clearing dense forests drastically decreases overall plant transpiration, which completely reduces the critical moisture actively available in the surrounding atmosphere for natural cloud formation.

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (A)

The assertion is completely true as massive deforestation is directly linked to distinctly reduced local precipitation. The reason is also true and provides the precise scientific explanation.

Trees constantly release large amounts of water vapour through transpiration. Removing them drastically cuts atmospheric moisture, which significantly hinders normal cloud formation and rainfall.

26. Match the deeply interconnected major Earth spheres carefully with their appropriate physical components or detailed examples:

	List-I (Earth's Sphere)		List-II (Example/Component)
P.	Lithosphere/Geosphere	1.	Vast living mangroves and vibrant coral reefs
Q.	Hydrosphere	2.	The massive solid Deccan plateau and heavy soil
R.	Cryosphere	3.	The frozen polar ice caps and Himalayan glaciers
S.	Biosphere	4.	The expansive Brahmaputra river system and deep groundwater

- (A) P-1, Q-3, R-4, S-2
 (B) P-2, Q-4, R-3, S-1
 (C) P-3, Q-2, R-1, S-4
 (D) P-4, Q-1, R-2, S-3

Ans : (B)

The geosphere includes solid terrestrial formations like the Deccan plateau and various soil layers. The hydrosphere comprises all liquid water, including vast river systems and groundwater. The cryosphere exclusively contains solid water forms like massive glaciers and ice caps. The biosphere uniquely encompasses all living organisms and their respective natural habitats.

27. Carefully arrange the following complex sequential events in their proper chronological order regarding the delicate global energy balance precisely from the Sun to the Earth:

1. Re-radiated infrared radiation steadily warms the Earth's lower surface again.
2. Slowly outgoing heat is partially trapped continuously by atmospheric greenhouse gases.
3. Dangerous short wavelength UV radiation is mostly absorbed entirely by the upper ozone layer.

4. The slightly warmed Earth's surface actively re-radiates invisible thermal heat completely back into the lower atmosphere.
5. Bright visible light effectively provides vital energy for photosynthesis and partially warms the solid land.

- (A) 3, 5, 1, 4, 2
 (B) 5, 3, 4, 1, 2
 (C) 3, 1, 5, 2, 4
 (D) 5, 1, 3, 4, 2

Ans : (A)

Incoming solar radiation first encounters the upper atmosphere where the ozone layer absorbs most ultraviolet rays. Visible light then penetrates to reach the surface, providing crucial energy and warmth. The surface absorbs this energy and subsequently re-radiates it as outgoing infrared heat, which is finally trapped by atmospheric greenhouse gases.

28. Carefully read the following complex statements firmly regarding the massive destructive impact of severe atmospheric changes entirely on the Earth's biosphere:

1. A much warmer atmosphere strictly holds much less moisture, completely leading to universal global droughts everywhere.
2. Rapidly melting massive glaciers add immense water to rivers, eventually heavily threatening highly populated coastal cities with dangerously rising sea levels.
3. Completely sudden violent bursts of intense rainfall can heavily erode top soil and vastly reduce gentle groundwater recharge.
4. Immensely increased atmospheric CO₂ heavily makes massive ocean water distinctly more acidic, tragically threatening vital plankton and sensitive coral reefs.

Which of these statements are scientifically correct?

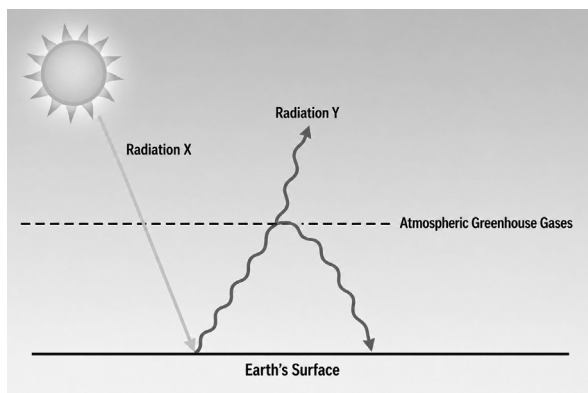
- (A) 1, 2, and 3
 (B) 2, 3, and 4
 (C) 1, 3, and 4
 (D) 1, 2, 3, and 4

Ans : (B)

A progressively warmer atmosphere actually holds much more moisture, which causes highly intensified monsoons in some regions alongside severe droughts in others. Melting glaciers definitively raise global sea levels, seriously threatening coastal settlements. Furthermore, intense sudden rainfall causes severe soil erosion,

while excessive atmospheric carbon dioxide demonstrably increases damaging ocean acidity.

29. Analyze the atmospheric interaction depicted in the diagram. What do the different arrow styles most likely represent regarding the Earth's energy balance?



- (A) Radiation X is mostly visible light, and Radiation Y is infrared radiation trapped by greenhouse gases.
 (B) Radiation X is ultraviolet radiation absorbed by the ozone layer, and Radiation Y is visible light.
 (C) Radiation X is outgoing infrared radiation, and Radiation Y is incoming solar insolation.
 (D) Radiation X represents low-frequency radio waves, and Radiation Y represents high-frequency gamma rays.

Ans : (A)

Radiation X represents incoming shortwave solar radiation, primarily visible light, which easily passes through the atmosphere. Radiation Y represents outgoing long wave infrared radiation emitted by the Earth's surface. Greenhouse gases trap and re-radiate this infrared radiation downwards, creating the greenhouse effect. The other options incorrectly swap these radiation types or fundamentally misidentify the atmospheric layer's specific function.

30. What critical scientific environmental trend does the famous Keeling curve primarily and clearly depict?
- (A) The rapid and severe depletion of the protective ozone layer located directly over Antarctica since 1980.
 (B) The steady and unprecedented rise in global atmospheric carbon dioxide concentrations since 1960.

- (C) The massive seasonal variation in incoming solar insolation smoothly changing from the equator directly to the poles.
 (D) The drastically changing global surface water temperatures measured carefully over the entirely last heavily industrialized century.

Ans : (B)

The Keeling curve is a highly significant scientific graph that clearly depicts the continuous and unprecedented rise in atmospheric carbon dioxide concentrations. Starting from the year nineteen sixty, it visually documents how global carbon dioxide levels have steadily increased by roughly thirty-five percent, largely driven by intense human industrial activities.

31. Based on the temperature gradients in the table, what specific wind movement will occur at 2:00 PM?

Time of Day	Temperature of Mountain Slope (°C)	Temperature of Valley Floor (°C)
2:00 PM	30	24
2:00 AM	12	18

- (A) Cool air will flow down the slopes into the valley to create a mountain breeze.
 (B) Cool air will rise from the valley floor causing rapid condensation and rainfall.
 (C) Warm air will descend from the mountain slopes pushing cold air out of the valley.
 (D) Cooler air from the valley will move up the heated slopes as a valley breeze.

Ans : (D)

At 2:00 PM, the mountain slopes are significantly warmer than the valley floor. The air over the heated slopes expands and rises, creating a low-pressure region. Consequently, the cooler, denser air from the valley floor moves upward along the slopes to replace the rising warm air, forming what is known as a valley breeze.

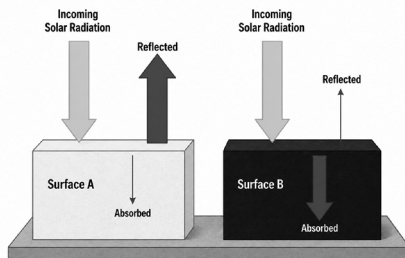
32. High in the massive Northern Hemisphere, massive surface ocean currents smoothly forming large continuous circular patterns heavily called gyres generally rotate in exactly which specific direction due largely to the spinning Earth's rotation?
- (A) Counter-clockwise
 (B) Clockwise
 (C) Directly north to south
 (D) Alternating directions every single season

- (D) During a typical mountain breeze, distinctly warm air from the high slopes rapidly sinks deep into the valley.

Ans : (D)

The incorrect statement describes warm air sinking during a mountain breeze. In reality, after sunset, the mountain slopes lose heat rapidly and become much cooler than the valley floor. Consequently, the air over the slopes becomes colder and denser, completely causing this cold air to flow downward into the valley.

18. Based on the interaction of incoming radiation with the two distinct material blocks, identify the most accurate classification of the surfaces.



- (A) Surface A represents a dark asphalt road, and Surface B represents a glacier.
 (B) Surface A will experience a rapid temperature increase compared to Surface B.
 (C) Surface A represents a high albedo surface like snow, and Surface B represents a low albedo surface like dark soil.
 (D) Surface A and Surface B reflect identical amounts of radiation but differ in their specific heat capacities.

Ans : (C)

Surface A reflects most incoming radiation and absorbs very little, indicating a high albedo surface like snow or ice. Surface B absorbs most radiation, representing a low albedo surface like dark soil. Option C correctly identifies this relationship. Options A and B incorrectly assign high absorption to high albedo or misrepresent expected heating rates. Option D is factually incorrect.

19. What is the primary ecological consequence when excessive nitrogen-based agricultural fertilisers are aggressively washed away into nearby natural water bodies?
 (A) It instantly increases the maximum oxygen-holding capacity of the deeply polluted water.
 (B) It aggressively leads to massive algal blooms that actively deplete oxygen and kill local fish.

- (C) It powerfully neutralises the harsh acidity of the vast surrounding oceanic water immediately.
 (D) It rapidly decreases the average surface temperature of the completely polluted water body.

Ans : (B)

When agricultural fertilisers containing excessive nitrates are washed into rivers and lakes, they cause a phenomenon known as eutrophication. This nutrient overload stimulates the massive and widespread growth of algae. As these immense algal blooms eventually decay, they heavily deplete dissolved oxygen in the water, inevitably leading to the death of fish.

20. **Assertion (A):** The planet Venus is noticeably hotter than Mercury despite Mercury being located significantly closer to the Sun.
Reason (R): Venus completely lacks any atmosphere, fully allowing all incoming massive solar radiation to strike its harsh surface directly.
 (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is not the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Ans : (C)

The assertion is true because Venus exhibits higher surface temperatures than Mercury. However, the reason provided is entirely false. The extreme heat on Venus is precisely due to the presence of a massive, dense atmosphere predominantly composed of greenhouse gases, which naturally causes an intense and uncontrolled greenhouse effect.

21. Consider the following complex statements specifically addressing the incredibly slow phase of the global carbon cycle:
 1. It constantly operates over a brief period of days to years entirely through the rapid process of photosynthesis.
 2. Dead plants and animals slowly get buried and chemically converted to dense fossil fuels over millions of years.
 3. Tiny marine organisms effectively use dissolved atmospheric carbon dioxide to form protective shells that eventually sink to the dark ocean floor.

Which of the statements given above are scientifically correct?

rays are spread out over much larger areas, causing colder conditions.

36. Which microorganism group in the table performs the process of denitrification to maintain the atmospheric balance?

Microorganism Group	Reactant Processed	Product Formed
Group 1	Atmospheric nitrogen gas	Ammonia
Group 2	Ammonia	Nitrites and nitrates
Group 3	Nitrates in soil	Atmospheric nitrogen gas
Group 4	Organic waste matter	Ammonia

- (A) Group 1 organisms
(B) Group 2 organisms
(C) Group 3 organisms
(D) Group 4 organisms

Ans : (C)

Denitrification is the biological process where specialized bacteria convert soil nitrates back into atmospheric nitrogen gas, completing the cycle. The table clearly indicates that Group 3 processes nitrates into nitrogen gas. Group 1 performs nitrogen fixation, Group 2 carries out nitrification, and Group 4 is responsible for the ammonification of organic waste material.

37. Which deeply important and highly successful global international agreement specifically and strictly aimed at aggressively reducing the widespread industrial use of highly destructive chlorofluorocarbons (CFCs) to effectively protect the fragile atmospheric ozone layer?
- (A) The Kyoto Protocol
(B) The Paris Agreement
(C) The Montreal Protocol
(D) Mission LiFE

Ans : (C)

The Montreal Protocol is a highly successful international global agreement specifically designed to aggressively phase out the widespread industrial production of chlorofluorocarbons. These harmful artificial chemicals were severely destroying the protective stratospheric ozone layer. Following strict global cooperation, the

damaged ozone layer is now finally showing clear signs of slow recovery.

38. **Assertion (A):** The massive continuous burning of ancient carbon-rich fossil fuels actively adds vast quantities of completely vital oxygen strictly back into the atmosphere.

Reason (R): Industrial combustion is essentially a vigorous chemical process that heavily and continuously consumes vast amounts of atmospheric oxygen completely while releasing massive carbon dioxide.

- (A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (D)

The assertion is entirely false because the burning of fossil fuels actually removes oxygen from the atmosphere rather than adding it. The reason accurately explains the chemical reality of combustion, which is a vigorous oxidation process that actively consumes life-sustaining oxygen gas while simultaneously releasing large amounts of carbon dioxide.

39. Carefully consider the following highly specific statements regarding the precise vertical thermal structure of the massive Earth's strictly organized atmospheric layers:

1. The atmospheric temperature continuously and steadily decreases with increasing height strictly in the lowest troposphere at a rough rate of roughly $6.5^{\circ}\text{C}/\text{km}$.
2. The exact maximum structural height of the entire troposphere is significantly found directly above the freezing polar regions.
3. The slightly warmer stratosphere strictly contains the highly protective ozone layer which completely absorbs incoming harmful UV rays.

Which of the statements given above are scientifically completely correct?

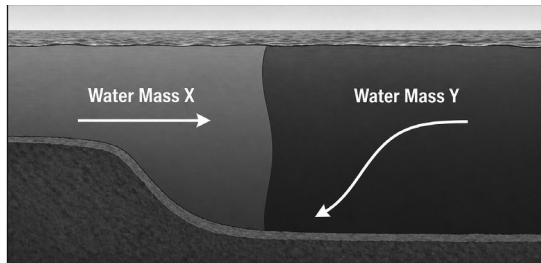
- (A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 1, 2, and 3

Ans : (C)

In the lowest atmospheric layer, the troposphere, the temperature steadily decreases with altitude.

The stratosphere firmly sits above it and crucially houses the protective ozone layer. However, the statement claiming the troposphere's height is maximum over the poles is incorrect; it is actually highest directly above the warm equatorial regions.

40. The diagram shows the cross-section of an ocean where two distinct water masses are interacting. Which of the following conditions strictly explains the downward movement of Water Mass Y?



- (A) Water Mass Y has a significantly higher temperature and lower salinity than Water Mass X.
- (B) Water Mass Y is experiencing strong surface planetary winds pushing it downward.
- (C) Water Mass Y has a lower temperature and higher salinity than Water Mass X.
- (D) Water Mass Y has a lower density than Water Mass X due to high evaporation rates.

Ans : (C)

The diagram shows Water Mass Y sinking beneath Water Mass X. In ocean currents, denser water sinks below less dense water. Seawater density increases with lower temperatures and higher salinity. Therefore, Water Mass Y must be colder and saltier than Water Mass X. Warm or less salty water remains near the surface. Other options contradict the fundamental principles of water density.

41. Which of the following precisely structured biological sequences accurately represents the strictly correct natural sequence of vital nitrogen gas conversions completely making it totally available directly to green terrestrial plants?
- (A) Atmospheric $N_2 \rightarrow$ Nitrites $\rightarrow$ Ammonia $\rightarrow$ Nitrates
 - (B) Atmospheric $N_2 \rightarrow$ Ammonia $\rightarrow$ Nitrites $\rightarrow$ Nitrates
 - (C) Atmospheric $N_2 \rightarrow$ Nitrates $\rightarrow$ Nitrites $\rightarrow$ Ammonia
 - (D) Atmospheric $N_2 \rightarrow$ Ammonia $\rightarrow$ Nitrates $\rightarrow$ Nitrites

Ans : (B)

The biological nitrogen cycle follows a specific vital sequence. Initially, specialized nitrogen-fixing bacteria completely convert inert atmospheric nitrogen gas directly into usable ammonia. Subsequently, nitrifying bacteria systematically convert this ammonia first into intermediate nitrites, and then finally into nitrates, which complex plant roots can efficiently assimilate from the surrounding soil.

42. Which detailed and specific scientific statement regarding the massive continuous global hydrological water cycle is strictly highly INCORRECT?
- (A) Massive continuous transpiration actively occurring from countless terrestrial plants powerfully contributes massive water vapour completely to the surrounding atmosphere.
 - (B) Heavy condensed precipitation naturally returns fresh water securely to the planetary surface completely in the diverse form of rain, hail, or snow.
 - (C) Deep slow infiltration entirely refers specifically to massive flood water flowing extremely rapidly entirely over the solid surface to violently reach the ocean.
 - (D) The continuous dynamic water cycle actively transports completely crucial minerals and dissolved nutrients safely to the vast oceans, heavily supporting diverse marine life.

Ans : (C)

The incorrect statement drastically misdefines infiltration. In reality, infiltration is the crucial slow process where surface water gently seeps downward deeply into the soil and permeable rocks, effectively recharging vital underground aquifers. The rapid movement of excess water strictly over the solid surface is properly referred to as surface runoff.

43. Which specific immense planetary atmospheric pressure belts are steadily and continuously formed precisely when dense heavy air cools significantly and rapidly sinks downward specifically around thirty degrees North and South planetary latitudes?
- (A) Equatorial low pressure belts
 - (B) Sub-polar low pressure belts
 - (C) Sub-tropical high pressure belts
 - (D) Polar high pressure belts

Ans : (C)

Intense solar heating heavily warms the air near the equator, causing it to rise rapidly and move steadily poleward. As this warm air reaches higher altitudes, it cools significantly, becomes much denser, and forcefully sinks back downward specifically near thirty degrees North and South latitudes, creating massive sub-tropical high-pressure belts.

44. What environmental phenomenon is most likely responsible for the data trends observed at Site C?

Lake Testing Site	Agricultural Runoff Detected (Nitrate level)	Dissolved Oxygen Concentration (mg/L)	Fish Population Status
Site A	Low	8.5	Healthy
Site B	Moderate	6.0	Declining
Site C	Very High	2.1	Severe Mortality

- (A) Increased global warming causing rapid evaporation of lake water
 (B) Excessive carbon dioxide absorption leading to severe ocean acidification
 (C) Depletion of the ozone layer increasing ultraviolet radiation exposure
 (D) Eutrophication causing algal blooms and subsequent oxygen depletion

Ans : (D)

The table shows that high nitrate levels from agricultural runoff at Site C correspond to critically low dissolved oxygen and severe fish mortality. This demonstrates eutrophication, where excessive nutrients trigger massive algal growth. When these algae eventually die, decomposing bacteria consume the available dissolved oxygen in the water, creating lethal conditions for aquatic life.

45. The massive fast-flowing Gulf Stream is essentially a distinctly warm global ocean current that vigorously flows completely towards the northwestern rugged coast of heavy Europe. What exactly is its deeply primary environmental effect entirely on this specific region specifically during winter?
- (A) It drastically and instantly freezes the major deep ports completely due entirely to sudden excessive rapid water evaporation.
 (B) It violently and directly causes completely severe long droughts locally by vastly heavily decreasing surrounding atmospheric moisture

everywhere.

- (C) It smoothly keeps many heavy major coastal ports completely fully ice-free and gently thoroughly moderates the harsh regional climate.
 (D) It entirely actively completely deflects the heavy massive planetary prevailing winds continuously fully backwards completely towards the hot equator.

Ans : (C)

Ocean currents strongly regulate the global climate by efficiently transporting immense amounts of heat. The Gulf Stream powerfully carries very warm water entirely from the southern part of the North Atlantic directly to northwestern Europe. This continuous warming effect moderates the harsh winter climate, crucially keeping numerous strategic European ports completely ice-free.

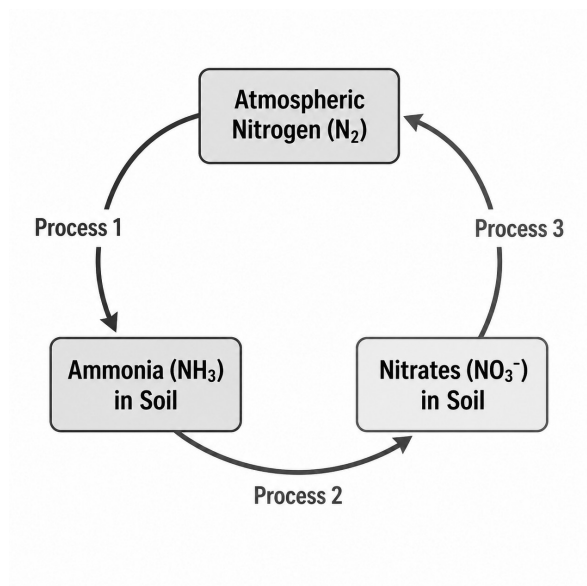
46. Why exactly is the massive vast global ocean technically completely strictly considered a hugely massive natural global reservoir that deeply and perfectly regulates highly fluctuating atmospheric carbon dioxide levels everywhere?
- (A) It forcefully and perfectly permanently traps completely all incoming massive atmospheric carbon dioxide safely as deeply pure freezing liquid carbon.
 (B) It actively and heavily absorbs vast atmospheric CO₂ to smoothly naturally form massive stable chemical carbonate and bicarbonate ions internally.
 (C) It intensely naturally constantly boils everywhere, smoothly releasing massive vast amounts of pure vital oxygen entirely to safely heavily replace carbon.
 (D) It extremely actively entirely transforms dissolved deadly carbon dioxide violently completely directly entirely into pure completely inert freezing nitrogen gas.

Ans : (B)

The vast global oceans act as an enormous and essential carbon sink. They continuously absorb massive quantities of carbon dioxide directly from the atmosphere. Once dissolved in the water, this carbon dioxide chemically reacts to efficiently form stable carbonate and bicarbonate ions, deeply regulating the planet's sensitive overall carbon balance.

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47. The flowchart represents key biological transformations in an elemental cycle. Identify the specific processes occurring at positions 2 and 3.



- (A) Process 2 is ammonification, and Process 3 is nitrification.
 (B) Process 2 is nitrogen fixation, and Process 3 is assimilation.
 (C) Process 2 is assimilation, and Process 3 is ammonification.
 (D) Process 2 is nitrification, and Process 3 is denitrification.

Ans : (D)

Process 2 represents the biological conversion of ammonia into nitrites and then nitrates, a crucial step called nitrification performed by nitrifying bacteria. Process 3 represents the conversion of nitrates back into atmospheric nitrogen gas, a step known as denitrification, performed by denitrifying bacteria. Process 1 represents nitrogen fixation. The alternative options incorrectly label these highly specific sequential steps.

48. Carefully read the following deeply important official statements specifically strictly about the global environmental Mission LiFE (Lifestyle for Environment):
1. It is exactly an actively India-led massively important global initiative smoothly introduced at the massive UN Climate Change Conference essentially in 2021.
 2. It strongly effectively explicitly encourages regular common people thoroughly to deeply

adopt perfectly mindful, completely highly eco-friendly daily lifestyle habits everywhere.

3. It legally totally aggressively firmly demands the rapid incredibly immediate violent total shutdown of absolutely all massive heavy fossil fuel power plants globally.
4. It powerfully firmly crucially heavily highlights deeply how simple actions completely of individuals and dedicated local communities can absolutely smoothly massively help build a beautifully sustainable future.

Which of these complex statements are actually completely accurate entirely based strictly on the provided textbook text?

- (A) 1, 2, and 4
 (B) 2, 3, and 4
 (C) 1, 3, and 4
 (D) 1, 2, 3, and 4

Ans : (A)

Mission LiFE is a highly significant India-led global environmental initiative successfully introduced during the twenty twenty-one UN Climate Change Conference. It strongly encourages adopting mindful, eco-friendly daily habits and firmly highlights the immense power of individual community actions in building sustainability. It does not mandate shutting down global power plants.

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49. What is the precise scientific definition of 'insolation' as provided in the chapter?
- (A) The outgoing infrared radiation permanently trapped by atmospheric greenhouse gases.
 - (B) The fraction of solar radiation immediately reflected by a bright surface.
 - (C) The amount of the Sun's radiation that actually reaches the Earth's surface.
 - (D) The high frequency electromagnetic waves constantly emitted by the Earth's hot core.

Ans : (C)

The Sun continuously emits massive amounts of radiant energy across space. The specific portion of this incoming solar radiation that successfully penetrates the atmosphere and ultimately reaches the Earth's surface is precisely defined as insolation. It is fundamentally responsible for significantly warming both the terrestrial surface and the surrounding atmosphere.

50. Scientists at the Indian Institute of Tropical Meteorology (IITM), Pune, use advanced computer models to simulate the Indian monsoon. What specific environmental data do they primarily couple to study how global warming may change rainfall patterns?

(A) Only the changing wind speeds isolated over the vast Thar desert.
 (B) The continuous energy flows between the atmosphere, oceans, land, and ice.
 (C) The exact number of trees actively planted in northern Himalayan valleys.
 (D) The specific daily variations in lunar gravitational pull on local tides.

Ans : (B)

Advanced researchers at the Indian Institute of Tropical Meteorology utilize highly complex computer models to accurately forecast monsoon patterns. To achieve this, they meticulously couple the massive continuous energy flows interacting dynamically across the Earth's atmosphere, deep oceans, solid landmasses, and polar ice, effectively analyzing profound global warming impacts.

51. Identify the correctly matched pair of the Earth's specific atmospheric layer and its key distinguishing feature:

(A) Troposphere - Temperature sharply increases with altitude.
 (B) Stratosphere - The region containing the protective ozone layer.
 (C) Mesosphere - Where almost all active weather formation takes place.
 (D) Exosphere - The lowest atmospheric layer resting directly on the ground.

Ans : (B)

The Earth's atmosphere is strictly organized into distinct functional layers. The troposphere is the lowest layer where temperature steadily decreases with altitude and weather actively forms. The stratosphere, located immediately above it, critically contains the dense ozone layer which completely absorbs harmful ultraviolet radiation, causing its temperature to significantly increase.

52. Which of the following are specific biological examples of nitrogen-fixing bacteria explicitly mentioned in the textbook?

(A) Nitrosomonas and Nitrobacter
 (B) Rhizobium and Azotobacter
 (C) Pseudomonas and various fungi
 (D) Phytoplankton and massive marine corals

Ans : (B)

The biological nitrogen cycle relies heavily on specialized microscopic organisms. Certain vital nitrogen-fixing bacteria, specifically Rhizobium found safely inside the root nodules of leguminous plants, alongside free-living Azotobacter actively residing in the soil, possess the unique ability to efficiently convert totally unreactive atmospheric nitrogen gas directly into highly usable ammonia.

53. Clouds play a highly dual role in the Earth's energy balance. They absorb and reflect some incoming sunlight, but what is their other major vital function?

(A) They completely block all incoming radio waves from deep outer space.
 (B) They actively release heavy chlorofluorocarbons into the pure upper atmosphere.
 (C) They absorb surface-radiated heat, preventing it from escaping into space.
 (D) They quickly destroy the upper ozone layer during heavy thunderstorms.

Ans : (C)

The atmosphere acts as a vital protective thermal blanket. While clouds partially reflect and absorb incoming energetic solar radiation, they also play a hugely crucial secondary role. They actively absorb outgoing infrared heat previously re-radiated from the warmed Earth's surface, effectively preventing this vital thermal energy from simply escaping into space.

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54. Which of the following is NOT an active reservoir that continuously cycles carbon within the highly active fast carbon cycle?

(A) Deeply buried ancient fossil fuels
 (B) Atmospheric carbon dioxide gas
 (C) Living green terrestrial plants
 (D) Massive oceanic phytoplankton populations

Ans : (A)

The fast carbon cycle operates very rapidly over periods ranging from days to a few years, actively involving atmospheric carbon dioxide, living plants, marine phytoplankton, and respiring animals. Conversely, the deep burial and complex conversion of ancient dead organic matter into fossil fuels strictly belongs to the incredibly slow carbon cycle.

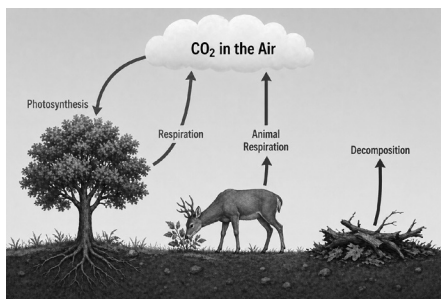
- 101.** What are ocean currents? How do variations in temperature and salinity drive the movement of dense water at deeper levels of the global oceans?

Ans :

Ocean currents are the continuous, directed movements of large masses of ocean water across the globe. At deeper levels, their movement is primarily driven by variations in water density, which depends on temperature and salinity. Warm, equatorial waters have lower salinity and remain near the surface. In contrast, colder waters moving from the poles are much denser due to low temperatures and higher salinity. These dense waters sink beneath the lighter surface waters, driving a slow, deep-ocean circulation pattern worldwide.

- 102.** Draw a schematic diagram of the carbon cycle showing its main processes. Explain how carbon rapidly moves from the biosphere to the atmosphere in the fast cycle.

Ans :



The fast carbon cycle operates rapidly over days to years, primarily involving living organisms. Plants extract atmospheric carbon dioxide and utilise sunlight to convert it into glucose through the process of photosynthesis. This carbon becomes the fundamental building block of the plant. When plants and animals undergo cellular respiration to generate energy, or when they eventually die and decompose, this stored carbon is swiftly released back into the atmosphere as carbon dioxide gas, completing this quick biological cycling loop.

- 103.** Explain how human-induced climate change is currently affecting the natural water cycle and impacting both coastal cities and agricultural sustainability in India.

Ans :

Climate change significantly disrupts the water cycle by creating a warmer atmosphere capable

of holding more moisture. This alteration leads to extreme weather patterns, causing intensified, heavy monsoons in certain regions while triggering severe droughts in others. Sudden, intense rainfall increases surface run-off and erosion, severely reducing the essential infiltration needed to recharge groundwater reserves. Without adequate groundwater, sustaining agriculture becomes incredibly difficult during extended dry months, threatening food security and severely impacting the livelihoods of farmers depending on reliable water.

- 104.** Trace the complete biological path of a nitrogen atom starting from the atmosphere, moving into a plant, then to an animal, and finally returning to the atmosphere.

Ans :

An atmospheric nitrogen atom is first converted into ammonia by nitrogen-fixing bacteria in legume root nodules. Soil bacteria then convert this ammonia into nitrites and subsequently into nitrates through nitrification. A plant absorbs these soluble nitrates from the soil to build proteins. When an herbivorous animal consumes the plant, the nitrogen is transferred into the animal's body. Upon the animal's death, decomposers convert its organic matter back into ammonia. Finally, denitrifying bacteria convert soil nitrates back into atmospheric nitrogen gas.

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- 105.** Differentiate between the fast and slow carbon cycles. Provide one clear example of a biological or geological process involved in each cycle.

Ans :

The fast carbon cycle involves the rapid exchange of carbon between living organisms and the atmosphere, typically occurring over days to years. A primary example is photosynthesis, where plants continuously absorb atmospheric carbon dioxide. In contrast, the slow carbon cycle operates over millions of years, involving long-term geological transformations. An example is the formation of fossil fuels, where dead organic matter gets buried deep under intense pressure and heat, locking away carbon in the form of coal or oil for millennia.

VERY SHORT ANSWER

59. Define the biosphere as mentioned in the Earth system.

Ans :

The biosphere comprises all living organisms and their natural habitats, including diverse ecosystems like mangroves, forests, farms, ocean plankton, and coral reefs.

60. What is the cryosphere in the context of Earth's spheres?

Ans :

The cryosphere refers to the solid form of water on Earth, which includes ice and snow like the Himalayan glaciers and polar ice caps.

61. Name the type of waves through which solar radiation reaches the Earth.

Ans :

Solar radiation reaches the Earth as electromagnetic waves, which can easily travel through a vacuum at the incredibly high speed of light.

62. What is the approximate value of the solar constant?

Ans :

The solar constant is approximately 1.4 kilowatts per square metre, or about 1400 joules per second per square metre at the atmosphere's top.

63. What is the scientific term for the fraction of solar radiation reflected by a surface?

Ans :

The scientific term for the fraction of incoming solar radiation that is reflected back by a specific surface is known as its albedo.

64. Why do snow and ice remain very cold despite receiving solar radiation?

Ans :

Snow and ice have a remarkably high albedo, meaning they heavily reflect most of the incoming solar radiation rather than absorbing it.

65. What causes the urban heat island effect in modern cities?

Ans :

Modern cities use materials like concrete and asphalt that strongly absorb incoming solar radiation and release it later, keeping urban areas warmer than rural villages.

66. State one difference between the troposphere and the stratosphere regarding temperature change.

Ans :

In the troposphere, temperature steadily decreases with height, whereas in the stratosphere, the temperature actually increases with altitude due to solar ultraviolet absorption.

67. What is the primary function of the ozone layer in the stratosphere?

Ans :

The ozone layer acts as a vital protective shield by strongly absorbing harmful ultraviolet radiation from the Sun, safely safeguarding living organisms on Earth.

68. Give one example of a greenhouse gas and state its role.

Ans :

Carbon dioxide is a key greenhouse gas that efficiently traps outgoing infrared heat, actively preventing it from escaping and keeping the Earth suitably warm.

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69. What would happen to Earth's temperature if it had no atmosphere?

Ans :

Without its thick protective atmosphere to continuously trap outgoing radiated heat, the Earth would become far too intensely cold for most life to survive.

70. What causes the formation of a valley breeze during the day?

Ans :

Mountain slopes typically heat up much faster than the valley floor during daytime, causing warm air to swiftly rise and cooler air to climb.

55. What is the precise and correct meaning of the term 'biogeochemical cycle' as detailed in the chapter?
- (A) The complete mechanical weathering of massive rocks exclusively by deep river currents.
 - (B) The cyclic movement of vital matter and energy between abiotic and biotic environmental components.
 - (C) The totally irreversible chemical burning of ancient fossil fuels yielding dense greenhouse gases.
 - (D) The continuous linear flow of intense solar radiation directly from the Sun to outer space.

Ans : (B)

Living organisms and their surrounding physical environment are intimately connected. A biogeochemical cycle specifically refers to the dynamic, continuous, and purely cyclic movement of essential matter and energy flowing smoothly between the non-living abiotic components and the living biotic components of various interconnected ecosystems, ensuring total global environmental stability.

56. Why exactly is bright visible light specifically crucial for naturally sustaining most complex terrestrial life forms on Earth?
- (A) It permanently destroys the deadly ultraviolet radiation before it reaches the surface.
 - (B) It aggressively forces atmospheric nitrogen to rapidly combine with soil minerals.
 - (C) It provides the essential primary energy driving the process of photosynthesis.
 - (D) It actively boils deep ocean water to rapidly power the global water cycle.

Ans : (C)

The Sun continuously emits a broad spectrum of electromagnetic radiation. The specific portion consisting of bright visible light is absolutely vital because it provides the immense primary energy required by green plants to successfully perform photosynthesis. This crucial biological process sustainably produces the foundational food supporting almost all living terrestrial organisms.

57. What is the strictly defining functional characteristic of the exosphere precisely in the context of Earth's overall atmospheric structure?
- (A) It represents the direct starting boundary of the vast outer space region.

- (B) It contains the highest absolute concentration of protective ozone gas molecules.
- (C) It is the lowest atmospheric layer immediately touching the solid terrestrial surface.
- (D) It is the exact exclusive location where powerful planetary winds are actively generated.

Ans : (A)

The Earth's immense atmosphere is carefully structured into several highly distinct vertical layers based on temperature variations. Above the high thermosphere lies the incredibly thin exosphere, starting approximately at a lofty altitude of one hundred kilometres. This extremely sparse outermost atmospheric layer represents the definitive starting boundary of empty outer space.

58. How did the pioneering Indian atmospheric scientist Anna Mani's early work directly contribute to India's modern environmental and energy infrastructure?
- (A) She successfully invented the chemical Haber-Bosch process to mass produce synthetic fertilizers.
 - (B) She meticulously mapped solar insolation, laying the firm foundation for immense solar energy deployment.
 - (C) She personally discovered the massive ozone hole hovering directly above the freezing continent of Antarctica.
 - (D) She originally drafted the official Montreal Protocol to completely ban harmful chlorofluorocarbon production globally.

Ans : (B)

Anna Mani was a highly pioneering Indian atmospheric scientist who meticulously mapped widespread solar insolation patterns across India. Her incredibly detailed measurements accurately highlighted the country's vast renewable solar energy potential. This deeply foundational work now crucially supports the massive large-scale deployment of modern solar power infrastructure across the entire nation.

83. Where does oxygen naturally exist in its securely combined chemical forms?

Ans :

Oxygen abundantly exists in highly stable combined forms deep within the Earth's hard crust as various metal oxides alongside essential atmospheric carbon dioxide gas naturally.

84. What would you observe in a water body heavily affected by agricultural eutrophication?

Ans :

You would prominently observe excessively widespread growth of harmful green algal blooms that drastically deplete available dissolved oxygen and unfortunately kill numerous aquatic fish populations.

85. Under what condition does harmful ground-level smog typically form in cities?

Ans :

Ground level smog usually forms when highly concentrated toxic vehicular emissions chemically react with intense natural sunlight, actively producing exceptionally dangerous local ozone layers.

86. What is the relationship between large-scale deforestation and natural surface albedo?

Ans :

Clearing vast natural forests drastically decreases important local plant transpiration and substantially alters the immediate surface albedo, significantly increasing surrounding environmental surface heat retention.

87. What is the globally recognised successful outcome of the Montreal Protocol?

Ans :

The globally supported Montreal Protocol successfully reduced the harmful worldwide usage of dangerous chlorofluorocarbons, powerfully allowing the damaged stratospheric ozone layer to slowly recover.

88. What is the primary gaseous composition of the Earth's atmosphere?

Ans :

The vast atmosphere primarily contains about 78 percent nitrogen gas and 21 percent oxygen,

alongside minor but very essential amounts of argon and carbon dioxide.

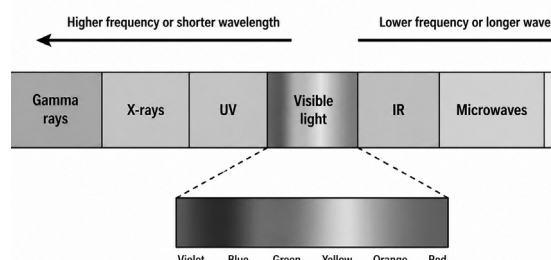
SHORT ANSWER QUESTIONS

89. Explain how a change in the cryosphere can lead to significant disruptions in the hydrosphere and the biosphere.

Ans :

The cryosphere includes solid water like glaciers and polar ice. If atmospheric temperatures rise, it accelerates the melting of these ice masses. This melted ice flows into lakes and oceans, significantly increasing water levels in the hydrosphere. Consequently, this can lead to severe flooding in low-lying areas and rising sea levels. Such flooding threatens coastal cities and disrupts natural ecosystems within the biosphere, eventually causing habitat loss for many terrestrial and marine organisms living in those vulnerable coastal regions.

90. Study the given diagram of the electromagnetic spectrum.



Which parts of this spectrum are most concentrated in the solar radiation reaching Earth? How does the Earth's atmosphere interact with UV and IR rays?

Ans :

The solar radiation reaching the Earth's surface is mainly concentrated in the ultraviolet (UV), visible light, and infrared (IR) ranges, constituting about 99 percent of the Sun's energy. Short wavelength UV radiation is mostly absorbed by the ozone layer located in the upper atmosphere, which protects life from harmful rays. Visible light reaches the surface to provide energy for photosynthesis. Infrared radiation warms the Earth's surface, and the outgoing heat is subsequently trapped by greenhouse gases, keeping the planet warm.

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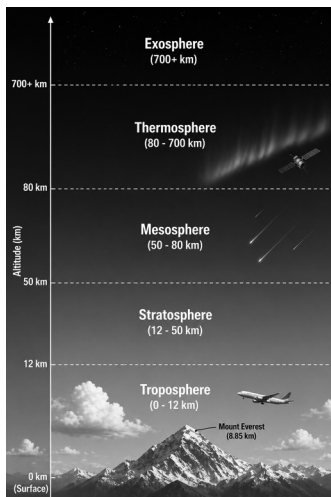
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91. Define insolation and the solar constant. Why is the maximum insolation actually reaching the Earth's surface lower than the value of the solar constant?

Ans :

Insolation is the amount of the Sun's radiation that successfully reaches the Earth's surface. The solar constant is the average amount of solar energy received per unit time per unit area perpendicular to the Sun's rays at the top of the atmosphere. The maximum insolation at the surface is lower than the solar constant because gases, clouds, and dust particles in the atmosphere absorb and scatter a significant portion of this solar energy before it can reach the ground.

92. Study the given diagram of atmospheric layers.



Identify the layer where almost all weather phenomena occur. Why does the temperature actively increase with altitude within the stratosphere?

Ans :

Almost all weather phenomena, such as clouds, winds, and storms, occur exclusively in the troposphere, which is the lowest atmospheric layer. In the layer directly above it, the stratosphere, the temperature actually increases with height instead of decreasing. This warming occurs because the stratosphere contains the ozone layer. Ozone molecules actively absorb high-energy ultraviolet (UV) radiation from the Sun. This absorption of UV energy generates heat, causing the upper regions of the stratosphere to be warmer than its lower regions.

93. What would happen to the Earth's average temperature if its atmosphere were completely removed? Explain your reasoning based on the greenhouse effect.

Ans :

If the Earth lacked an atmosphere, its average surface temperature would drop drastically, making it too cold for most life forms to survive. The atmosphere contains greenhouse gases like carbon dioxide, methane, and water vapour. These gases absorb the outgoing infrared heat re-radiated by the Earth's surface and trap it, preventing it from escaping into space. Without this natural greenhouse effect, all the re-radiated solar energy would be immediately lost to space, leaving the planet in a permanently frozen state.

94. Compare a snow-covered field and a patch of black soil with respect to their albedo and their ability to absorb incoming solar radiation.

Ans :

Albedo is the fraction of solar radiation reflected by a surface. Snow has a very high albedo, meaning it reflects a large proportion of incoming solar radiation and absorbs very little. Because of this high reflection, snow-covered regions remain incredibly cold. In contrast, black soil has a much lower albedo. It reflects very little light and efficiently absorbs a significant amount of the incoming solar radiation. Consequently, black soil heats up much more quickly and remains relatively warmer than snow.

95. A student claims that cities are generally warmer than surrounding rural areas during summer nights because concrete and asphalt reflect most of the solar radiation. Is this correct? Justify your answer.

Ans :

The student's claim is incorrect. Cities are warmer due to the Urban Heat Island effect, but not because concrete reflects radiation. Instead, materials like concrete, steel, and asphalt have low albedo; they actively absorb large amounts of solar radiation during the day and retain this heat. At night, these urban structures slowly re-radiate the trapped heat back into the surroundings. This continuous re-radiation warms the city air much more than in rural areas, which stay cooler through plant transpiration.

96. How does the spherical shape of the Earth and the permanent tilt of its rotational axis lead to the highly uneven heating of its surface?

Ans :

Due to the Earth's spherical shape, the Sun's rays strike different latitudes at varying angles. In equatorial regions, sunlight falls directly and is concentrated over a smaller area, leading to intense heating. Conversely, near the poles, the rays are slanted and spread over a larger area, resulting in colder conditions. Additionally, the Earth's tilted axis and its revolution around the Sun cause changing daytime lengths and seasonal variations, further contributing to the highly uneven distribution of solar radiation globally.

97. Explain the destructive process of eutrophication. How does the overuse of chemical fertilisers in agriculture lead to severe oxygen depletion in natural water bodies?

Ans :

Eutrophication is the rapid degradation of water bodies caused by nutrient pollution. When farmers overuse chemical fertilizers, excess nitrates and phosphates are washed into nearby rivers and lakes through surface runoff. These abundant nutrients trigger explosive, uncontrolled growth of algae, completely covering the water surface. As these massive algal blooms eventually die, naturally occurring decomposer bacteria consume massive amounts of dissolved oxygen to break them down. This severe oxygen depletion quickly suffocates fish and other aquatic life, causing massive die-offs.

98. Explain how the equatorial low-pressure belt is initially formed. How does the rising air from this equatorial region eventually create the sub-tropical high-pressure belts?

Ans :

The equatorial low-pressure belt is formed due to intense solar heating near the equator. This constant heating causes the warm, moist surface air to expand, become lighter, and rise vertically, creating a continuous zone of low pressure. As this warm air rises and moves toward the poles at higher altitudes, it gradually cools and becomes denser. Around 30° North and South latitudes, this heavy, cooled air inevitably sinks back towards the Earth's surface, creating the sub-tropical high-pressure belts.

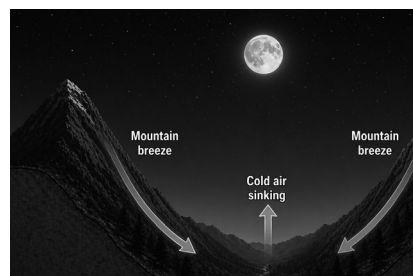
99. Why is the atmosphere absolutely crucial for regulating the Earth's overall climate? Explain the specific protective and warming roles played by the ozone layer and greenhouse gases.

Ans :

The atmosphere regulates Earth's climate by carefully managing incoming and outgoing energy. The ozone layer, located in the stratosphere, acts as a protective shield by absorbing harmful ultraviolet radiation from the Sun, preventing it from damaging living organisms. Simultaneously, greenhouse gases like carbon dioxide and water vapour trap outgoing infrared heat re-radiated by the Earth's surface. This trapped heat prevents energy from escaping entirely into space, maintaining a sufficiently warm and stable temperature that allows diverse life to survive.

100. Draw a neat diagram illustrating the mountain breeze. How do these daily changes in wind direction naturally benefit agriculture in Himalayan valleys like Dehradun?

Ans :



These local winds significantly influence the microclimate of mountainous valleys. By replacing the stagnant air, mountain breezes help regulate the nighttime temperature and moisture conditions in the valley. This regular air circulation prevents extreme frost settling, thereby protecting sensitive crops. It also supports better soil health by moderating evaporation rates. Consequently, agricultural practices in Himalayan valleys heavily depend on these daily wind reversals to maintain an environment suitable for crop growth and overall plant health throughout the shifting seasons.

- 71.** How is a mountain breeze different from a valley breeze?

Ans :

A mountain breeze flows downwards at night as slopes cool quickly, whereas a valley breeze rapidly flows upwards during the intensely heated daytime hours.

- 72.** What is the result of the Earth's rotation on planetary winds?

Ans :

The constant rotation gracefully deflects planetary winds toward the right in the Northern Hemisphere and toward the left in the Southern Hemisphere along curves.

- 73.** Define ocean gyres in the context of surface currents.

Ans :

Gyres are massive circular patterns of ocean water naturally formed when the Earth's continuous rotation strategically deflects large moving liquid masses across the sea.

- 74.** What is the climatic significance of the Gulf Stream?

Ans :

The powerful Gulf Stream heavily transports warm equatorial ocean water towards the northwestern coast of Europe, wonderfully keeping many crucial seaports completely free of ice.

- 75.** What is meant by a biogeochemical cycle in an ecosystem?

Ans :

It is the dynamic cyclic movement of essential matter and energy continuously flowing between the abiotic and biotic ecosystem components across Earth's various spheres.

- 76.** What causes the alarming rise in sea levels within the modern water cycle?

Ans :

An exceptionally warmer atmosphere constantly melts large polar glaciers, significantly adding extra liquid water to natural ocean basins and eventually raising massive global sea levels.

- 77.** Name the biological process through which plants convert atmospheric carbon dioxide into glucose.

Ans :

Living green plants effectively convert atmospheric carbon dioxide gas into useful glucose through the critical biological process widely known as natural solar photosynthesis.

- 78.** Why does burning fossil fuels drastically affect the natural carbon cycle?

Ans :

Burning fossil fuels excessively releases huge amounts of securely stored carbon back into the natural atmosphere very rapidly, significantly intensifying the dangerous greenhouse effect.

- 79.** What pioneering scientific contribution was made by Indian atmospheric scientist Anna Mani?

Ans :

Anna Mani brilliantly mapped crucial solar insolation across India, gracefully publishing the nation's incredibly important first comprehensive solar radiation atlas early in the year 1981.

- 80.** Name two nitrogen-fixing bacteria that convert atmospheric nitrogen into ammonia.

Ans :

Rhizobium organisms found inside root nodules of common legumes and Azotobacter bacteria in the soil efficiently convert unreactive atmospheric nitrogen into highly usable ammonia compounds.

- 81.** What is the specific process of nitrification in the nitrogen cycle?

Ans :

Nitrification is the vital bacterial process where Nitrosomonas initially converts ammonia into nitrite, and then Nitrobacter efficiently transforms that nitrite into extremely usable nitrate.

- 82.** Define denitrification as it occurs in nature.

Ans :

Denitrification is the final cyclical step where specialised soil bacteria, like Pseudomonas, successfully convert complex soil nitrates back into completely unreactive atmospheric nitrogen gas.

106. Explain how the excessive emission of carbon dioxide by human activities directly affects the chemistry of oceans and threatens the survival of delicate marine ecosystems.

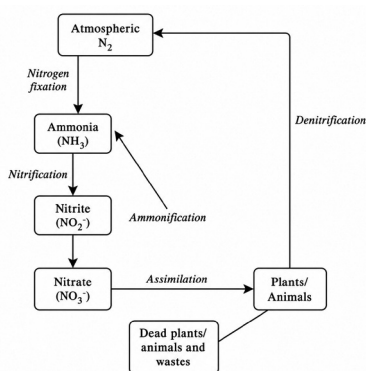
Ans :

When human activities release massive amounts of carbon dioxide into the atmosphere, a significant portion is absorbed by the world's oceans. This excess carbon dioxide reacts with seawater, drastically increasing ocean acidity. The increasingly acidic water severely disrupts the ability of marine organisms, such as tiny plankton and coral reefs, to build and maintain their delicate calcium carbonate shells. This widespread structural damage threatens the foundational base of marine food webs, ultimately jeopardizing the survival of entire ocean ecosystems globally.

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107. Draw a flowchart showing the main processes involved in the nitrogen cycle. Why is it absolutely necessary to convert atmospheric nitrogen gas before living organisms can use it?

Ans :



Although nitrogen is the most abundant gas in the Earth's atmosphere, it exists as a highly stable, non-reactive diatomic molecule. Plants and animals lack the biological mechanisms to utilise this raw gaseous nitrogen directly for synthesizing essential proteins and nucleic acids. Therefore, it must first be converted into reactive, soluble compounds, such as ammonia and nitrates, through nitrogen fixation. Once transformed by specific soil bacteria or lightning, these soluble nutrients can be easily absorbed and assimilated by plant roots.

108. What is the ozone layer and what vital protective role does it play? How do human-made chlorofluorocarbons (CFCs) chemically affect it, and what are the resulting consequences?

Ans :

The ozone layer is a crucial protective shield located within the stratosphere. It plays a vital role by absorbing the majority of the Sun's high-energy, harmful ultraviolet radiation, safeguarding earthly life from severe skin and eye damage. However, manufactured chemicals called chlorofluorocarbons (CFCs), formerly used in refrigerants and aerosols, drift into the stratosphere and destroy ozone molecules at an alarming rate. This chemical destruction thins the ozone layer, creating "holes" that allow dangerous levels of UV radiation to penetrate downwards.

109. Describe how massive ocean currents play a significant role in regulating the Earth's climate, using the warm Gulf Stream as a specific example.

Ans :

The Gulf Stream is a highly powerful, warm ocean current that originates near the equator and flows rapidly northward along the eastern coast of North America. As it extends across the Atlantic Ocean towards the northwestern coast of Europe, it carries a massive amount of tropical heat. This continuous delivery of warm water significantly moderates the European climate. By warming the surrounding air, it keeps many high-latitude ports entirely ice-free during harsh winters, creating unusually mild conditions for those regions.

110. A friend heavily claims that the greenhouse effect is entirely negative and we should aim to eliminate greenhouse gases completely to stop global warming. Do you agree? Justify.

Ans :

I disagree with this claim because the natural greenhouse effect is absolutely essential for survival. Greenhouse gases, like carbon dioxide and water vapour, trap a portion of the heat re-radiated by the Earth's surface. Without this critical heat-trapping mechanism, all thermal energy would escape directly into space, leaving the planet freezing and entirely uninhabitable. The actual danger lies in the enhanced greenhouse effect, where human activities generate excessive amounts of these gases, causing unnatural, rapid global warming and climate disruption.

QUESTIONS:

- Which highly abundant but non-reactive gas in the atmosphere is Ramesh referring to?
- What is the name of the special microscopic helpers (bacteria) that live in the root nodules of legumes?
- What specific role do these bacteria play in the nitrogen cycle?
- Contrast Ramesh's biological method with the artificial production of nitrogen fertilizers (like the Haber-Bosch process) in terms of environmental impact.

Ans :

- Ramesh is referring to nitrogen gas (N_2).
- The bacteria living in the root nodules are Nitrogen-fixing bacteria, such as Rhizobium.
- These bacteria perform nitrogen fixation; they convert atmospheric nitrogen (N_2) into ammonia (NH_3) or soluble compounds that plants can easily absorb from the soil.
- Ramesh's biological method is natural, maintains soil health, and is eco-friendly. In contrast, the Haber-Bosch process is highly energy-intensive (using 1-2% of global energy), and the overuse of such artificial fertilizers can degrade soil and pollute water bodies.

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- 136.** A local fishing community relies on a large freshwater lake for their livelihood. Over the past five years, intensive agriculture relying heavily on nitrate fertilizers has expanded around the lake. Following an unusually heavy monsoon season, massive amounts of agricultural runoff washed into the lake. Within weeks, the lake surface was entirely covered in a thick, green blanket of algae. Shortly after this 'algal bloom', fishermen were devastated to find thousands of dead fish floating near the shores, and the water emitted a foul odor.

QUESTIONS:

- What is the scientific term used to describe the process where excessive nutrients cause widespread algal growth in a water body?
- How did the heavy monsoon season contribute to this ecological disaster?
- Explain the biological reason why the fish died following the massive algal bloom.

Ans :

- The term for this process is eutrophication.
- The heavy monsoon rains caused intense runoff, washing excessive nitrate fertilizers from the surrounding agricultural lands directly into the lake, providing excessive nutrients for algae.
- The massive growth of algae eventually depletes the dissolved oxygen in the water. Without sufficient oxygen, aquatic life such as fish cannot survive and suffocate, leading to their death.

- 137.** During a museum exhibition on human technology, a guide pointed out an old refrigerator from the 1970s. She explained that appliances from this era utilized synthetic chemicals called CFCs for cooling. While effective, these gases drifted high into the sky, where they destroyed a critical layer of gas faster than nature could rebuild it. This thinning created a massive "hole" over Antarctica, threatening global health. Fortunately, nations across the world united to sign a historic treaty to ban these chemicals, and today, that atmospheric layer is slowly healing.

QUESTIONS:

- What does the acronym CFC stand for?
- Which critical layer of the atmosphere was being destroyed by these chemicals?
- What is the name of the historic global agreement that successfully reduced the use of CFCs?
- According to the text, why was the thinning of this layer considered a major threat to living organisms?

Ans :

- CFC stands for chlorofluorocarbons.
- The ozone layer (located in the stratosphere) was being destroyed by these chemicals.
- The global agreement is known as the Montreal Protocol.
- The thinning of the ozone layer was a major threat because it allowed harmful ultraviolet (UV) radiation from the Sun to reach the Earth's surface in greater amounts. Increased UV radiation can harm living organisms, damage ecosystems, and cause health issues like skin cancer and eye damage in humans.

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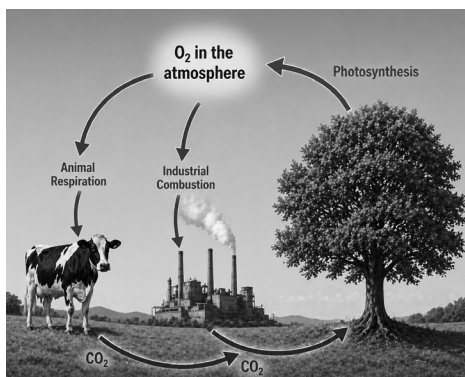
116. Explain the immense significance of the Montreal Protocol in actively addressing a global environmental crisis directly related to the Earth's upper atmosphere.

Ans :

In the late twentieth century, scientists discovered that synthetic chlorofluorocarbons (CFCs) were rapidly destroying the crucial stratospheric ozone layer, threatening to expose earthly life to lethal ultraviolet radiation. Recognising this dire global emergency, nations worldwide collaborated to create the Montreal Protocol. This landmark international agreement strictly regulated and phased out the production of ozone-depleting chemicals. Thanks to this unprecedented global scientific cooperation, the ozone layer is now successfully recovering, demonstrating that coordinated human action can effectively restore damaged planetary systems.

117. Draw a labelled diagram showing the cyclic flow of oxygen in nature. Explain how plants and animals actively work together to maintain the balance of atmospheric oxygen.

Ans :



Plants and animals work together to perfectly maintain atmospheric balance. During cellular respiration, all animals and plants continuously consume atmospheric oxygen to break down glucose for vital energy, subsequently releasing carbon dioxide as a metabolic by product. Simultaneously, green plants perform photosynthesis during daylight hours. They absorb this accumulated carbon dioxide from the air and, using solar energy, convert it back into essential glucose while releasing fresh oxygen. This continuous biological exchange ensures oxygen levels remain remarkably stable across the planet.

118. What is the primary objective of Mission LiFE? How can individual citizens actively contribute to maintaining planetary environmental balance through their everyday lifestyle actions?

Ans :

Mission LiFE (Lifestyle for Environment) is a global initiative that strongly encourages individuals to adopt mindful, eco-friendly lifestyles to combat climate change. Its primary objective is to replace unsustainable consumption habits with sustainable practices. Individual citizens can actively contribute by making simple everyday changes, such as conserving water, reducing energy usage, actively recycling materials, and minimising food waste. By consciously reducing their personal carbon footprints, communities can collectively decrease greenhouse gas emissions and significantly help restore the Earth's delicate environmental balance.

LONG ANSWER QUESTIONS

119. (a) What is the fundamental difference between the fast and slow carbon cycles?
(b) How do human activities, specifically the burning of fossil fuels, disrupt this natural cycle?

Ans :

- (a) The fast carbon cycle occurs over days to years, where plants convert atmospheric carbon dioxide into glucose using sunlight through photosynthesis. Carbon dioxide is then released back into the atmosphere through respiration by plants and animals. When these organisms die, decomposition also returns carbon to the environment. Conversely, the slow cycle occurs over millions of years, where dead plants and animals get buried under immense pressure and are converted into fossil fuels like coal, oil, and gas, storing carbon for extensive periods.
(b) Excessive burning of these fossil fuels releases massive amounts of this stored carbon back into the atmosphere on a very short time scale. This rapid release overwhelms natural carbon sinks like oceans and forests, leading to an increased concentration of greenhouse gases, which intensifies the greenhouse effect, causes global warming, and alters global climate patterns drastically.

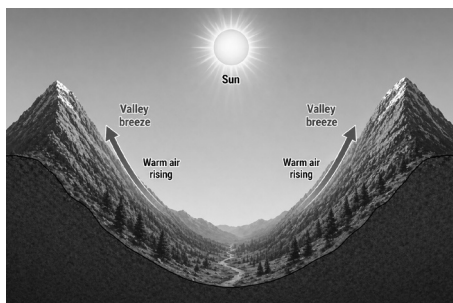
111. What would specifically happen to the direction of planetary winds if the Earth were perfectly stationary and did not rotate on its axis? Explain your reasoning.

Ans :

If the Earth were completely stationary and did not rotate, planetary winds would blow in simple, perfectly straight lines directly from high-pressure areas to low-pressure areas. The intense equatorial heat would cause air to rise and flow straight toward the poles, while cold polar air would sink and flow straight toward the equator. However, because the Earth rotates, the Coriolis effect is generated. This invisible force continuously deflects the moving winds into curved paths, creating complex, global circulation patterns.

112. Draw a labelled diagram illustrating the formation of a valley breeze. Explain the mechanism of how and when this breeze occurs in mountainous regions.

Ans :



During the day in mountainous regions, the mountain slopes heat up much more rapidly than the valley floor. Consequently, the air directly above these heated slopes becomes warm, expands, and rises, creating a low-pressure zone. To fill this newly created void, cooler and denser air from the valley floor moves upward along the slopes. This continuous daytime flow of cooler air rushing up the mountainsides to replace the rising warm air is scientifically known as a valley breeze.

113. Explain how biogeochemical cycles fundamentally represent a dynamic, continuous interaction between the biotic and abiotic components of the Earth's natural ecosystems.

Ans :

Biogeochemical cycles involve the continuous, cyclic movement of essential elements like carbon, nitrogen, and oxygen between living

organisms (biotic) and their physical environment (abiotic) including air, water, and soil. Organisms continuously extract these vital nutrients from the non-living spheres to build their bodily structures and generate energy. Through natural processes like respiration, excretion, and eventual decomposition, these exact same elements are faithfully returned to the physical environment. This perpetual exchange strictly maintains environmental balance and successfully sustains all global life.

114. Compare the crucial processes of nitrification and denitrification in the nitrogen cycle strictly based on the specific microorganisms involved and the resulting chemical transformations.

Ans :

Nitrification is primarily carried out by specific soil bacteria like *Nitrosomonas* and *Nitrobacter*. During this essential process, toxic ammonia present in the soil is progressively oxidised first into nitrites, and subsequently into nitrates, which are easily absorbed by plants. In direct contrast, denitrification is performed by completely different bacteria, such as *Pseudomonas*. This reversing process takes the excess nitrates remaining in the soil and reduces them back into inert, gaseous atmospheric nitrogen, successfully completing the global biogeochemical cycling loop.

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115. Why does the large-scale clearing of massive forests frequently result in a severe increase in soil erosion and a noticeable decline in local rainfall?

Ans :

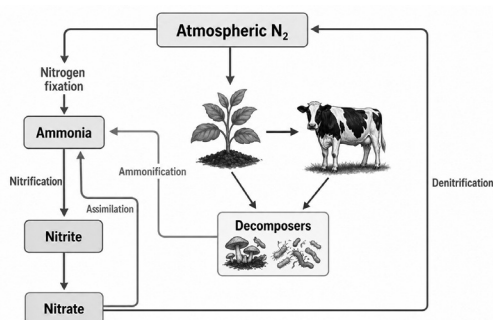
Forests play a critical role in anchoring the physical environment. When massive numbers of trees are removed, their extensive root systems, which firmly hold the topsoil together, decay. Without these roots, the vulnerable soil is easily washed away by rain or blown away by wind, severely increasing soil erosion. Furthermore, trees naturally release vast amounts of water vapour through transpiration. Clearing forests drastically reduces this essential atmospheric moisture, which subsequently lowers cloud formation and significantly decreases local rainfall patterns.

- (c) For example, the Gulf Stream is a very powerful, warm ocean current that carries warm water from the southern part of the North American east coast across the Atlantic Ocean. It flows toward the northwestern coast of Europe, providing a moderating influence that keeps many European ports comfortably ice-free even during severe winter months.

123. (a) Can you draw a flowchart depicting the complex nitrogen cycle?
(b) What are the specific roles of nitrogen-fixing bacteria and denitrifying bacteria in maintaining the critical nitrogen balance in the atmosphere?

Ans :

- (a)



- (b) Nitrogen is crucial for synthesizing proteins and nucleic acids in all living organisms, but atmospheric nitrogen gas is non-reactive and cannot be directly utilized by most plants and animals. Nitrogen-fixing bacteria, such as *Rhizobium* found in the root nodules of leguminous plants, and *Azotobacter* in the soil, play a vital role by converting this inert atmospheric nitrogen into ammonia. This ammonia is then further processed into soluble nitrates that plants can readily absorb from the soil to support their growth. Conversely, denitrifying bacteria, such as *Pseudomonas*, perform the crucial task of converting these soil nitrates back into nitrogen gas. This biological process releases the nitrogen back into the atmosphere, thereby completing the biogeochemical cycle and ensuring a stable, continuous balance of nitrogen in the ecosystem, preventing the permanent depletion of this essential atmospheric gas.

124. (a) How are local winds like valley and mountain breezes formed?
(b) Why do these daily wind reversals occur and what is their significance for agriculture and daily life in hilly regions?

Ans :

- (a) Valley and mountain breezes are local winds formed primarily due to the uneven heating and cooling of mountain slopes and valley floors. During the daytime, the mountain slopes facing the Sun heat up much faster than the shaded valley floor below. The air directly above these warm slopes becomes lighter and rises, creating a low-pressure region. Consequently, cooler and denser air from the valley moves up the slopes to fill this gap, forming a valley breeze.
(b) After sunset, the process reverses entirely. The mountain slopes lose heat rapidly and cool down faster than the valley floor. The air over the slopes becomes cold and heavy, flowing down into the valley under the influence of gravity, which generates a mountain breeze. These daily local winds are incredibly significant because they help regulate temperature, influence moisture conditions, and support vital agriculture in hilly regions.

125. (a) How would you briefly describe the geosphere, hydrosphere, and biosphere?
(b) How can a significant change in the cryosphere directly impact both the hydrosphere and the biosphere, explained with an appropriate example?

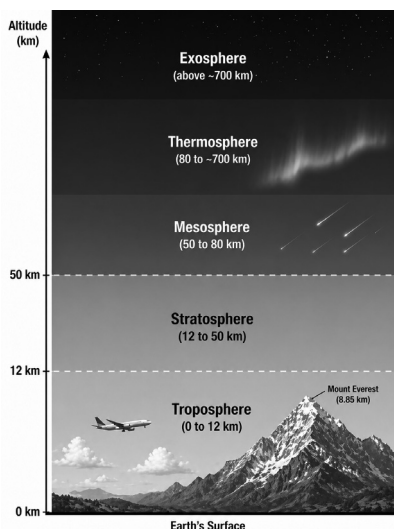
Ans :

- (a) The geosphere comprises the Earth's solid rocks, soil, landforms, and interior structure. The hydrosphere includes all liquid water on Earth, such as oceans, rivers, lakes, and groundwater. The biosphere encompasses all living organisms and their respective habitats across the planet.
(b) All these spheres are deeply interconnected, meaning a disturbance in one easily cascades into the others. For instance, if atmospheric temperatures rise, it accelerates the melting of glaciers and polar ice caps within the cryosphere. This excess melted ice directly enters the hydrosphere, significantly raising global sea levels. The elevated sea levels then

120. (a) Can you draw a labelled diagram showing the layers of the Earth's atmosphere?
- (b) Why does the temperature decrease with height in the troposphere but increase with height in the stratosphere?
- (c) What is one key feature of each of these two layers?

Ans :

(a)



- (b) It is heated primarily from the Earth's surface below, which absorbs solar radiation and warms the air just above it. Consequently, as warm air rises and expands, the temperature steadily decreases with increasing height in this layer. This crucial layer absorbs harmful ultraviolet radiation from the Sun, converting this high-energy radiation into heat. Because this heat absorption occurs predominantly in the upper regions of the stratosphere, the temperature actually increases with height.
- (c) The troposphere is the lowest atmospheric layer where virtually all weather phenomena, such as cloud formation and precipitation, occur. In contrast, the stratosphere is located directly above the troposphere and contains the vital ozone layer. This temperature inversion creates a highly stable atmospheric layer lacking vertical air mixing, which keeps weather strictly confined to the troposphere below and allows commercial aircraft to fly smoothly.

121. (a) What is the definition of the term 'solar constant' and what is its approximate value?
- (b) Why is the actual insolation reaching the Earth's surface lower than the solar constant?
- (c) How do you calculate the solar energy received by a 2 m^2 area in 30 minutes if the insolation on the Earth's surface is 800 W m^{-2} ?

Ans :

- (a) The solar constant is the average amount of solar energy received per unit time per unit area that is perpendicular to the Sun's rays at the top of the Earth's atmosphere. Its approximate value is 1.4 kilowatts per square metre.
- (b) However, the actual insolation reaching the Earth's surface is lower than this value because a significant portion of the incoming solar energy is absorbed, scattered, and reflected by gases, clouds, and dust particles present in the atmosphere before it can reach the ground.
- (c) To calculate the solar energy received, we use the formula: Energy equals Intensity multiplied by area and time. Given Intensity is 800 watts per square metre, Area is two square metres, and Time is thirty minutes, which equals eighteen hundred seconds. Energy equals 800 multiplied by 2 multiplied by 1800. Therefore, the solar energy received is 2,880,000 Joules.

122. (a) What is the definition of ocean currents and what are two major factors that drive them?
- (b) How do ocean currents play a fundamental role in regulating the Earth's climate?
- (c) How can you illustrate your answer with the example of the Gulf Stream?

Ans :

- (a) Ocean currents are the continuous, predictable movements of large masses of ocean water across the globe. These massive flows of water are primarily driven by planetary pressure differences, strong planetary winds that drag the surface water due to friction, and variations in water temperature and salinity.
- (b) Ocean currents play a fundamental role in regulating the Earth's climate by transporting immense amounts of heat from the warm equator towards the frigid poles, thereby effectively reducing extreme temperature differences across the planet.

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farming communities are struggling to grow crops, and wild animals have lost their natural habitats. Scientists studying the region noted that these local events are a direct reflection of broader global climate shifts.

QUESTIONS:

- (a) Identify any two Earth 'spheres' interacting in this scenario.
- (b) What is the immediate cause of the local lakes overflowing in the valleys?
- (c) How does this scenario illustrate that a disturbance in one sphere leads to changes in another?

Ans :

- (a) The spheres interacting in this scenario include the cryosphere (glaciers), hydrosphere (mountain lakes/floods), geosphere (topsoil), and biosphere (forests/animals/crops). (Any two can be identified).
- (b) The immediate cause of the local lakes overflowing is the unusually warm summer temperatures that accelerated the melting of the Himalayan glaciers, adding excess water to the lakes.
- (c) This scenario illustrates inter connectedness because a change in the atmosphere (warmer temperatures) affects the cryosphere (melting glaciers). This extra water disturbs the hydrosphere (flooding lakes), which in turn damages the geosphere (soil erosion) and disrupts the biosphere (loss of habitats and crops).

- 129.** During a summer trip to Goa, Rohan packed several essential items. He bought a high SPF sunscreen and UV-protective sunglasses. At the beach, while his family enjoyed the sunshine, Rohan observed that the sand became incredibly hot by midday, radiating heat that he could feel even without touching it. Later, he visited a nearby eco-resort where they were using a solar cooker with shiny reflective mirrors to boil rice using sunlight. Rohan wondered how energy from a source millions of kilometers away could cause sunburn, heat the ground, and cook food all at once.

QUESTIONS:

- (a) Which part of the electromagnetic spectrum is primarily responsible for causing sunburn, prompting Rohan to use sunscreen?

- (b) What happens to the short wavelength UV radiation before it reaches the Earth's surface?
- (c) Compare the energy levels of UV rays and visible light.
- (d) Explain how infrared (IR) radiation is involved in heating the sand and keeping the Earth warm.

Ans :

- (a) Ultraviolet (UV) radiation is primarily responsible for causing sunburn and damaging the skin.
- (b) Short wavelength UV radiation is mostly absorbed by the ozone layer located in the Earth's upper atmosphere, which protects life on the surface.
- (c) UV rays have a shorter wavelength and higher frequency than visible light, meaning they carry much higher energy compared to the visible light from the Sun.
- (d) The Earth's surface (like the sand) absorbs visible light and partly warms up. It then re-radiates this heat back as infrared (IR) radiation. A portion of this outgoing IR heat is trapped by greenhouse gases, keeping the environment warm.

- 130.** A city planning committee is designing a new residential complex to cope with increasingly hot summers. The chief architect, Ms. Sharma, insists on banning traditional black asphalt for the roads, proposing light-colored concrete instead. Furthermore, she mandates that all rooftops must be painted white or covered with rooftop gardens. During a presentation to the builders, she showed thermal imaging maps comparing the city center, which glowed deep red with trapped heat, to the cooler, green rural outskirts. She explained that their material choices could significantly alter local climate conditions.

QUESTIONS:

- (a) What scientific term describes the fraction of solar radiation reflected by a surface?
- (b) Why did Ms. Sharma propose light-colored concrete instead of black asphalt for the roads?
- (c) What phenomenon is responsible for the city center being hotter than the surrounding rural areas?

- (d) How do rooftop gardens (vegetation) help in keeping the environment comparatively cooler?
- (e) If the builders decided to use dark-colored roofs instead, predict the impact on the building's energy consumption.

Ans :

- (a) The fraction of solar radiation reflected by a surface is called its albedo.
- (b) Light-colored concrete has a high albedo, meaning it reflects more sunlight and stays comparatively cooler. Black asphalt has a low albedo, absorbing more solar radiation and heating up quickly.
- (c) This phenomenon is known as the Urban Heat Island effect, where cities with concrete, steel, and asphalt absorb and retain more heat than rural areas.
- (d) Vegetation helps keep the environment cooler through shade and plant transpiration, providing a natural cooling effect compared to artificial building materials.
- (e) If dark-colored roofs were used, they would absorb more solar radiation and heat up the building. This would increase the indoor temperature, leading to a higher energy demand for air conditioning to cool the building.

- 131.** Captain Aisha was piloting a commercial flight from Delhi to London. To avoid the heavy thunderstorms and turbulent clouds below, she ascended to an altitude of about 14 kilometers, cruising smoothly in the lower part of the next atmospheric layer. The in-flight display showed the outside temperature was freezing, yet Aisha knew that slightly higher up in this layer, the temperature actually begins to rise. She announced to the passengers that they were flying safely above the weather and sitting just beneath a crucial protective shield of gas.

QUESTIONS:

- (a) In which layer of the atmosphere do almost all weather phenomena, like the thunderstorms Aisha avoided, take place?
- (b) Name the atmospheric layer where Captain Aisha is cruising.
- (c) Why does the temperature increase with height in the layer where Aisha is flying, unlike the layer below it?

- (d) What is the crucial protective shield Aisha mentioned, and why is it important for life on Earth?

Ans :

- (a) Almost all weather phenomena take place in the troposphere.
- (b) Captain Aisha is cruising in the stratosphere (specifically, the lower stratosphere, which starts above 12 km).
- (c) The temperature increases with height in the stratosphere because it contains the ozone layer, which absorbs high-energy UV rays from the Sun, heating up the atmosphere in that region.
- (d) The protective shield is the ozone layer. It is crucial because it acts as a shield that absorbs harmful ultraviolet (UV) radiation from the Sun, which can damage eyes and skin, and harm living organisms and ecosystems.

- 132.** A group of hikers set up their camp in a deep Himalayan valley. During the late afternoon, they enjoyed a warm, refreshing breeze blowing upwards from the valley floor along the mountain slopes. However, after the sun set and they gathered around their campfire, they noticed a distinct change. A cold, dense wind began to blow downwards from the high mountain peaks into their campsite, making them shiver and forcing them to put on thick jackets.

QUESTIONS:

- (a) What name is given to the cool air flowing down from the slopes into the valley at night?
- (b) Explain the mechanism that causes the wind direction to reverse after sunset.
- (c) How do these daily wind changes benefit the mountainous regions?

Ans :

- (a) The cool air flowing down into the valley at night is called a mountain breeze.
- (b) After sunset, the mountain slopes lose heat faster and become cooler than the valley floor, which remains relatively warmer. The air over the slopes cools, becomes denser, and sinks down into the valley, creating a mountain breeze.
- (c) These local winds help regulate temperature, moisture conditions, and support soil and crop health in hilly regions, influencing daily life and agriculture.

- 133.** A maritime logistics company is charting a route for a cargo ship travelling from the eastern coast of North America to Northwestern Europe during winter. The navigation team plans to position the ship within a massive, fast-moving stream of ocean water that flows across the Atlantic. By riding this continuous movement of water, the ship saves fuel. Furthermore, the crew notices that despite the high latitudes and winter season, the coastal ports they arrive at in Europe remain completely free of ice, allowing for year-round trade.

QUESTIONS:

- What is the continuous movement of large masses of ocean water called?
- Identify the specific warm ocean current mentioned in this scenario that travels towards Europe.
- What drives the surface waters of the oceans to form these massive currents?
- How does this ocean current affect the climate and human activities in Northwestern Europe?

Ans :

- The continuous movement of large masses of ocean water is called an ocean current.
- The specific current is the North Atlantic Drift (an extension of the Gulf Stream).
- Surface ocean currents are primarily driven by strong planetary winds that drag the surface water due to friction.
- The current transports warm water from the equator towards the poles. This moderates the climate of Northwestern Europe, keeping its ports ice-free during winter, which supports year-round human activities like trade and commerce.

- 134.** For her science fair project, Priya built a closed ecosystem in a large glass jar. Inside, she placed rich soil, a small fern, some moss, and a few earthworms. She sealed the jar completely so no air could enter or leave and placed it near a bright window. Over the next few weeks, she observed condensation on the glass and noted that the fern continued to grow green leaves. She explained to the judges that even though the jar was sealed, the vital element forming the backbone of life was constantly moving between the living things and the air inside the jar.

QUESTIONS:

- Name the process by which the fern removes carbon dioxide from the air inside the jar to grow.
- How do the earthworms and the fern ensure that carbon dioxide is returned to the air within the sealed jar?
- Which type of carbon cycle (fast or slow) is being demonstrated in Priya's jar? Justify your answer.
- What forms the largest oceanic reservoir of carbon on a global scale?
- Predict what would happen to the carbon cycle in the jar if Priya placed it in complete darkness for a long period.

Ans :

- The process is photosynthesis.
- Both the earthworms and the fern return carbon dioxide to the air through the process of respiration. (Decomposition by microbes in the soil also releases CO_2).
- The fast carbon cycle is demonstrated here. This is because the exchange of carbon between the plants, animals (worms), and the atmosphere in the jar is happening over days and weeks, unlike the slow cycle which takes millions of years to form fossil fuels.
- The largest oceanic reservoir of carbon is formed by dissolved carbon dioxide (CO_2) and marine shells (carbonate and bicarbonate ions).
- In complete darkness, photosynthesis would stop, meaning CO_2 would no longer be absorbed by the fern. However, respiration would continue until oxygen runs out, leading to a buildup of CO_2 , eventual death of the organisms, and the collapse of the carbon cycle in the jar.

- 135.** Ramesh, an organic farmer, noticed his wheat yield was dropping year after year. Instead of buying factory-made chemical fertilizers, which use a lot of global energy to produce, he decided to plant a crop of chickpeas (a legume) in his field for one season. A few months later, he pulled up a chickpea plant and showed his son the small, bead-like nodules on its roots. He explained that special microscopic helpers lived in these nodules, pulling a vital, unreactive gas straight from the air and turning it into natural fertilizer for the soil.

severely impact the biosphere by flooding low-lying coastal regions, which destroys critical habitats like mangroves and coral reefs. This massive habitat loss threatens countless marine and terrestrial species, clearly demonstrating the delicate balance and profound interdependence of the Earth's continuous natural systems.

126. (a) What vital role do greenhouse gases play in supporting biological life on Earth?
 (b) How do human activities disrupt this natural balance?
 (c) What are the potential long-term consequences of this disruption?

Ans :

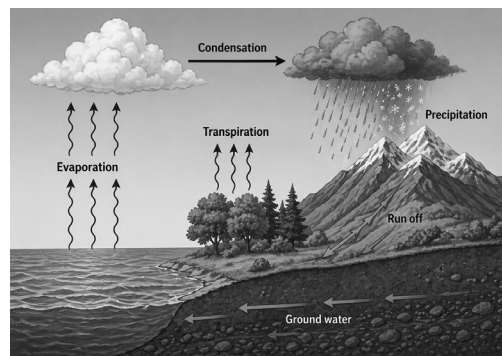
- (a) Greenhouse gases like carbon dioxide, methane, and water vapour play a crucial protective role by absorbing the infrared radiation re-radiated from the Earth's surface. They trap this outgoing heat, preventing it from escaping into space, thereby keeping the Earth warm enough to sustain biological life. Without this natural greenhouse effect, the planet would be dangerously cold.
- (b) However, human activities disrupt this delicate balance significantly. The extensive burning of fossil fuels for energy and widespread deforestation drastically increase atmospheric carbon dioxide levels. Simultaneously, agricultural practices and livestock rearing release massive amounts of methane. This excess concentration of greenhouse gases intensifies the heat-trapping effect, causing unnatural global warming.
- (c) The severe consequences include extreme weather patterns, accelerated melting of polar ice, rising sea levels threatening coastal cities, disrupted agricultural cycles, and immense biodiversity loss across various global ecosystems.

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127. (a) Can you draw a schematic diagram of the water cycle?
 (b) How does this cycle act as a vital link connecting the Earth's different spheres?
 (c) What specific impact does climate change have on this natural process?

Ans :

(a)



- (b) The water cycle continuously links all Earth's spheres through dynamic processes. Water evaporates from the hydrosphere and transpires from plants in the biosphere, entering the atmosphere as moisture. It then condenses and precipitates back to the surface, where it flows over the geosphere causing soil erosion, or infiltrates the ground to sustain plant life. It transports essential dissolved minerals from soil to oceans, directly supporting both terrestrial and marine ecosystems.
- (c) However, climate change severely disrupts this intricate cycle. A warmer atmosphere holds substantially more moisture, which leads to intense, concentrated rainfall and devastating floods in certain regions, while simultaneously causing prolonged droughts in others. Furthermore, sudden bursts of heavy rainfall increase rapid surface runoff, which significantly reduces the slow infiltration needed to recharge vital groundwater reserves, thereby threatening agricultural sustainability, drinking water supplies, and global food security.

CASE BASED QUESTIONS

128. A recent documentary highlighted the alarming changes occurring in the Himalayas. The film showed how unusually warm summer temperatures have accelerated the melting of ancient glaciers. This rapid melting has caused local mountain lakes to overflow, sending sudden, massive floods down into the valleys. The surging waters washed away large tracts of fertile topsoil and uprooted entire forests. Consequently, local

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